UNIV. OF
TORONTO
LIBRARY

Digitized by the Internet Archive
in 2008 with funding from
Microsoft Corporation

http://www.archive.org/details/engineeringcontr45chicuoft

F
Technol
E

Engineering and Contracting

Devoted to the Economics of Civil Engineering Design
and to Methods and Costs of Construction

VOLUME XLV

January-July, 1916

144616
6/12/17

THE MYRON C. CLARK PUBLISHING CO.
608 South Dearborn St., Chicago, Ill.

INDEX

VOL. XLV, JANUARY-JULY, 1916

GENERAL INDEX

A

- Accounting; Methods for Irrigation Projects 269
- Activated Sludge:
  - Chicago Stock Yards Sewage..... 388
  - Experimental Work, Milwaukee, Wis.. 104
  - New Data on..... 379
  - Process, Success of..... 97
  - Sewage Treatment.....208, 235
  - Winter Experience with..... 386
- Adding Machine; Precise Leveling Parties 540
- Air Compressors:
  - Balanced Piston Steam Valve Gears... 24
  - Fuel-Oil Driven 159
- Air Consumption; Pneumatic Tunnel Lining 33
- Alloy Steel; Advance in Commercial Production 124
- Alum; Effects on Brass Pipe in Filtering Water 398
- American Concrete Institute..... 34
- American Water Works Association..... 267
  - What Is Wrong with?..... 313
- Anniversary; Ten Years of Engineering and Contracting 1
- Aqueduct:
  - Los Angeles; History and Engineering Description 512
  - Los Angeles; Irrigation System of..... 82
  - Los Angeles; Relief Map for..... 480
  - Mechanical Cleaning Machine for..... 512
  - Winnipeg; Furnishing Sand and Gravel for 140
- Arches; Reinforced Concrete; Choosing Neutral Axes Curve..... 455
- Armor Plate; Government Regulation of Price 400
- Armory; Second Infantry, Chicago, Ill.. 431
- Articles:
  - Appeal to Limited Audience..... 553
  - Characteristics of Good Technical..... 359
  - Multiplication of Words in..... 401
  - Reviews and Summaries of Practice... 534
- Asphalt:
  - Breaking Up for Street Railway Construction 406
  - Employes; Profit-Sharing and Pensions for 229
  - Road Heater Snow Melting..... 413
  - Sewer Joints 192
- Association of Engineering Societies.... 92
- Automobiles (see also Motor Trucks):
  - Cost of Operating in Road Supervision 221, 283, 313, 414
  - Number in United States..... 125
- Azimuth; Device for Determining..... 129

B

- Bags; Cement, Plant for Cleaning..... 408
- Bidders; Making Available General Information for 224
- Bitumastic Fillers for Block Pavements. 166
- Bitumen Carpeted Concrete Pavement, Ann Arbor, Mich..... 363
- Bituminous Materials; Penetrating Needle for Testing.....363, 588
- Blast Furnaces; Minnesota Steel Co..... 154
- Block and Fall; Improved Form..... 588
- Blue Print Paper Holder..... 342
- Bonds; Serial, Study at Bucyrus, Ohio.. 80
- Bonuses; Award of..... 533
- Boulevards:
  - Cutting Grass on; Cost of..... 213
  - Resurfacing Bituminous Macadam..... 128
- Bridges:
  - Arch, Colorado River, Needles, Cal.... 472
  - Bascule; Three-track Trunnion; Chicago, Ill. 188
  - Bond Issue; Chicago..... 535
  - Distribution of Loads on Highway.... 92
  - Erection, Hell Gate Arch.....35, 77
  - Four Highway 549
  - Minimum Thickness of Steel..... 380
  - Painting and Maintaining..... 373
  - Pavement Construction for..... 591
  - Pier; Concrete, Cost of Constructing.. 474
  - Pier Design for Concrete Arch..... 32
  - Quebec, Erection Progress on..... 196
  - Reinforced Concrete, Bidding on..... 360
  - Reinforced Concrete, Cincinnati, O.... 263
  - Reinforced Concrete Curved Cord..... 160
  - Reinforced Concrete, Labor Cost-keeping System 142
  - Reinforced Concrete, Lawrence, Kan.. 35
  - Reinforced Concrete, Lyons Falls, N. Y. 160
  - Reinforced Concrete, Sweden.....343, 457
  - Snow Load for..... 409
  - Strength Required to Withstand Artillery Loads 177
  - Stresses, Temperature in Girder Spans 333
  - Timber Stringer Tests..... 427
  - Trunk Line Road Construction in Connecticut 324
  - Width of Concrete Slabs for; Tests... 447
  - Wooden Floor; Distribution of Loads on 92
- Buildings:
  - Armories, Design and Construction: Chicago 431
  - Arrangement and Requirements of Elevators for 452
  - Code, Revised, New York City..... 347
  - Column Moment and Deflection..... 101
  - Concrete, Wrecking with Explosives.. 293
  - Construction Plant for..... 433
  - Diagrams for Reinforced Concrete T-Beams 579
  - Edgewater Beach Hotel..... 278
  - Erection; Steel Erection Equipment for 413
  - Estimators' Reference Book..... 72
  - Foundation for Bank..... 389
  - Hollow Tile Wall Tests..... 139
  - Hotel; Lake Louise, Alberta, Can..... 299
  - Hotel Traymore, Atlantic City..... 14
  - Lives of; Erroneous Data..... 360
  - Methodist Book Concern, Cincinnati, O. 433
  - Minnesota Steel Co. Plant..... 154
  - Office Operating Costs..... 59
  - Regulations; Requirements of Different 204
  - Remington Arms & Ammunition Co... 278
  - Rushing Design and Construction..... 379
  - Sewage Pumping Station..... 18
  - Standardizing Commercial 267
  - Steel Column Tests..... 76
- Bulk Cement; Handling in Road Construction 415

C

- Cableways:
  - Aerial, Niagara Falls, Ont..... 274
  - Dragline Buckets for Levee Construction 528
- Carbon Dioxide Removal from Water.... 47
- Car Unloader 349
- Causeway; Long Pile Trestle..... 593
- Cement:
  - Bag Cleaning Plant..... 408
  - Bags; Cost of..... 129
  - Mill for Northwestern States..... 256
  - Natural; Can it Come Back?..... 443
  - Portable Storehouse for..... 483
  - Show, Associated Cement Company Exhibit 63
  - Storehouses; Portable Canvass..... 404
- Central Station Heating; Minnesota..... 356
- Cities:
  - Buying for, Practical Pointers..... 117
  - Reports; Interestingly Written..... 338
  - Standard Schedule for Grading..... 98
- Clearing Brush; Caterpillar Tractor for.. 527
- Cofferdam; Large, British Example of... 470
- Colliery Wastes in Germany..... 372
- Colloids in Engineering Structures..... 486
- Columns:
  - Bending Moment and Deflection in.... 226
  - Steel, Costs of..... 86
  - Subjected to Combined Bending and Compression 101
  - Tests, Special Committee Report..... 76
- Commission Government; Temptation to False Economy 291
- Compressed Air:
  - Concrete Tunnel Lining..... 29
  - Device for Cooling..... 528
- Compression Members; Designing for Small Stresses 375, 402
- Concrete:
  - Accelerating the Hardening..... 129
  - Aggregate Cost of Preparing..... 141
  - Aggregate, Practical Selection of..172, 225.
  - Aggregate, Rational Specification for.. 223
  - Aggregate, Rules for Selecting..... 34
  - Aggregate, Shrinkage in During Shipment 141
  - Bridge; Cincinnati, O..... 263
  - Bridge Pier Construction..... 474
  - Bridge Slabs, Tests of..... 447
  - Bridge Work; Cost-Keeping System... 142
  - Characteristics to Resist Sea Water... 469
  - Chutes, Inclination of.....34, 589
  - Conduit, Fall River, Mass..... 238
  - Construction; Arbitrary Standards.... 573
  - Construction Review Articles..... 27
  - Cottages for Sewage Farm Employes.. 505
  - Crossing Slabs 180
  - Deformation Under Loading..... 571
  - Drain Tile Tests..... 394
  - Effect of Alkali on..... 257
  - Effect of Duration of Mixing Period... 382
  - Gang Organization; Road Work..... .....177, 254, 463
  - Hydrated Lime Addition for Road Work 206
  - Improved Tamper for..... 587
  - Intercepting Drain, Fall River, Mass... 60
  - Jetty Head 138
  - Lining Irrigation Laterals..... 352
  - Lining Steel Syphons..... 416
  - Materials; Control in Aqueduct Construction 124
  - Mixer; Paving, Improved Form..... 208
  - Mixer, Compressed Air..... 29
  - Mixer, Four Cubic Yards..... 345
  - Mixer, Gravity with Hoisting Tower.. 68
  - Mixing Plant 433
  - Notable Combination of Opportunities for Study 75

Concrete (Continued).
  Piles 405
  Problems, Our Knowledge Concerning. 176
  Proportioning for Roads........ 41
  Reclaiming Stone from Old Macadam for 132
  Reinforcement Bar Splices........ 578
  Road Construction..........175, 314, 398, 399, 401, 415, 466
  Roads, Easton-Allentown, Pa........ 445
  Roads; General Discussion........ 385
  Roads, Maintenance of........ 435
  Roads, Philadelphia, Pa........ 390
  Roads; Reinforcement Prevents Cracking 424
  Roads, Study of Cracks in........ 357
  Sewer Construction; Experience in 11 Cities 277
  Sewer Construction, South Bend, Ind.. 137
  Shaft Lining 144
  Steam Jetted Tunnel Lining........ 181
  Stoppings for Mine Ventilation........ 129
  Strength of; Effect of Boiler Stack Gases 410
  Structures, Wrecking with Explosives. 293
  Tar Painting to Resist High Water Velocities 56
  T-Beams, Design of........ 579
  Temperature of Stresses in Girder Spans 333
  Viaduct, Toronto, Can. 280
  Tunnel Lining 29
  Plant, Chute, Slopes, Minimum........ 34
  Plant; Hotel Traymore, Atlantic City.. 15
  Plant, Savannah Terminal........ 12
  Plant for Shaft Lining........ 144
  Plant, Reinforced Concrete Viaduct.... 135
Conduits.
  Concrete; Fall River, Mass........ 238
  Three-level Reinforced Concrete........ 239
Construction Camp; Instructions and Outfit Required 516
Construction Changes, Recording........ 3
Construction Costs, Discussion of........ 220
Construction, Effect of High Prices on.. 444
Construction Plant:
  Building Reinforced Concrete........ 15
  Electric, for Sewers........ 16
  Reinforced Concrete Viaduct........ 134
  Roads and Streets........ 22
  Savannah Terminal 12
Construction Work, Car Shortage Prevention in 243
Contracting Firm, the Makings of a Good 423
Contractors:
  Blame for Failure of in Government Lock and Dam Construction........ 461
  Publicity Work by........ 27
Contracts:
  Delay in Signing, Dangers of........ 553
  Objectionable Clauses in........ 590
Conveyor for Unloading Cars........ 349
  Corrosion of Iron........ 72
Costs:
  Asphalt Sewer Joints........ 192
  Automobile Transportation for Engineers 284, 313
  Bank Protection; River Improvement.. 551
  Cement Bags 129
  Concrete Bridge Pier Construction.... 476
  Concrete Design and Construction.... 231
  Concrete Fence Posts........ 571
  Concrete Jetty Head........ 139
  Concrete Lining Irrigation Laterals.. 352
  Concrete Lining of Steel Syphons........ 418
  Concrete Mine Stoppings........ 129
  Concrete Pavement 127, 365
  Concrete Road Construction........108, 390
  Concrete Road; Illinois........ 571
  Concrete Road Maintenance........24, 435
  Concrete Roads, United States........ 330
  Concrete Shaft Lining........ 144
  Constructing Pile Driver Barge........ 406
  Corrugated Iron Culverts........ 588
  Cutting Grass on Boulevards........ 213
  Dragline Scraper Ditch Excavation.... 116
  Dredge Excavation of Drainage........ 120
  Ditch Excavation, with Templet-Excavator 128
  Data; Municipal, Methods of Recording 212
  Diversion Dam Construction........ 515
  Drainage Ditching 64
  Driving Heading in Hard Rock........ 558
  Engineering Supervision of Road Construction 451
  Gravel Roads in Clay County, Ia........ 460
  Hauling Gravel for Roads........23, 328
  Irrigation Structures 340
  Joint, Prorating Theory........2, 9
  Laboratory Tests of Road Materials... 473
  Maintaining and Operating Water Meters 180
  Maintaining Steel Pipe........ 367
  Oiling Earth Roads........ 85
  Paving 511
  Planting Small Trees at Reservoir.... 415
  Provision for Traffic During Road Construction 400
  Reinforced Concrete Retaining Wall... 207
  Reinforced Concrete Tank........ 91
  Remodeling Septic Tank........ 284
  Removing Concrete Pavement........ 410
  Moving Ferry Transfer Bridge........ 261
  Reservoir Improvement, Duluth........ 262
  Road Maintenance, New York........ 246
  Roads; Construction, New York State. 260
  Seeding a Small Park........ 211
  Sewage Treatment Plants in Illinois... 185
  Sewer Construction 64
  Sheet Asphalt and Brick Pavement... 495
  Spading and Raking Small Park........ 230
  Steam Shovel Grading of Roads........ 531
  Steel Pipe Manufacture........ 497
  Street Sprinkling, Portland, Ore........ 497
  Trimming Grass Along Walks and Curbs 237
  Unit in Construction........ 220

Costs (Continued).
  Using Valve Inserting Machine........ 507
  Water Service at Omaha, Neb........ 456
  Water Softening, Hinsdale, Ill........ 297
  Water Works Construction........ 182
  Well Drilling 570
  Wheel Type Excavator Operation........ 89
Cottages; Concrete, for Sewage Farm Employes 505
County Engineer, Rejuvenescence of.... 379
Criticism; Constructive, a Decade of.... 199
Crossing Slabs, Concrete........ 180
Culverts:
  Corrugated Iron; Cost of Installing.... 588
  Designed to Prevent Soil Erosion........ 588
  Precast Concrete Blocks........ 230
Curb:
  Grades at Street Intersections........ 346
  Integral Form for........ 544
  Method of Anchoring Pavement Base to 507
Cushions; Pavement, Analysis of........ 57

D

Dam:
  Charles River; Cleaning Lock Gate Trackways 404
  Concrete; Horizontal Joint Construction 593
  Cutoff Wall; Method of Grouting........ 412
  Diversion; Construction, Colorado River 514
  Drift Barrier; Washington........ 471
  Earth; Notes on Construction........ 293
  Elephant Butte 593
Dayton, Ohio, Flood Control Plans........ 382
Deep Cuts; Method of Excavating to Neat Lines 514
Deep Well Pumps........ 578
  Gas Engine Driven........ 495
Derricks:
  Depositing Beyond Reach of Boom.... 110
  Unusual and Effective Form of Pier.. 230
Diesel Engine; Effect on Fuel Supply and Cost 170
Disinfection of Water Supplies, Maryland Experiences 396
Disposal of Sewage........ 71
Diversion Dam; Novel Hydraulic Fill... 514
Drafting; Development of the Art........ 589
Drain:
  Intercepting, Fall River, Mass........ 60
  Tile; Tests on Supporting Strength.... 394
Drainage:
  Conference; Illinois 218
  Ditches; Open; Design and Construction 263
  Ditches, Unsightly Construction of.... 269
  Ditching; Templet Excavator........ 128
  Ditching, Wheel Type Excavator for.. 89
  Dragline Scraper Ditch Excavation.... 116
  Dredge Excavation 120
  Engineering, Michigan 152
  Engineers in Michigan, Status of........ 172
  Engineers, Salaries of........ 172
  Law, Minnesota 242
  Legislation, Suggestions for Needed... 305
  Method of Preventing Soil Erosion.... 548
  Pumping, Costs of........ 94
  Pumping Plant Operation........ 65
  Railway Roadbeds; Methods........ 173
  Straddle Ditch Excavation........ 63
Drawings:
  Filing and Indexing Methods; Washington, D. C........ 432
  Tracing Without Tracing Cloth........ 551
Dredges:
  Anchor Line Arrangement for........ 408
  Drainage Ditch Excavation by........ 120
  Hydraulic, Building Railway Embankment 129
  Operating in Drainage Ditches........ 120
  Rafts for Supplying Coal........ 529
  World's Record at Panama........ 407
Drift Barrier; Steel Cables and Concrete Piers 471
Drills; Wagon Mounted for Heavy Excavation 472
Dry Dock, San Francisco........ 442
Dynamite Thaw Kettle, Home-made.... 91

E

Earth Dam Construction; New Type of Construction 379
Editorial Plans for 1916........ 1
Editors; Salaried, for Engineering Societies 574
Efficiency, Railway Bridge and Building Department 39
Electric Freight Locomotive, Illustration of First 413
Electricity; Application to Sewerage...2, 16
Elevators; Buildings, Arrangement and Requirements of 452
Embankment; Building with Hydraulic Dredges 129
Engineering Ability, Illogical Methods of Rating 573
Engineering and Contracting Anniversary, Ten Year........ 1
  Editorial Plans, 1916........ 1
  Monthly Magazine Issues........ 509
  New Editorial Features........ 399
Engineering:
  Construction, Methods of Teaching.... 337
  Co-operation, Conference on........134, 375
  Co-operation 151
Co-operation, General Discussion of..... 303
  Curbing Commercialism by State Control 51
  Education, Signs of Distinct Progress in 244
  Ethics; Code for Western Society of Engineers 255
  Journals, Duty of Engineering Experts to 268

Engineering (Continued).
  Journals; Readers of, Co-operation by. 268
  Municipal and Sanitary........ 556
  Newspaper Publicity of........ 359
  Organization for Co-operation........ 214
  Organization for Publicity........135, 157
  Organizations, Need for Separate........ 27
  Popularized by Modern Toys........ 52
  Positions, Qualification of Men for.... 402
  Professors, Qualifications of........ 200
  Reports; Advantages of, at End of Construction 290
  Reports, False Economy in Publishing 313
  Schools; Use of Technical Journals.... 28
  Societies; Curtailing Power of Secretary 177
  Societies, Salaried Editors for........ 574
  State Highway Commission; Costs of. 153
  Supervision, Need of Proper........ 77
  Teachers; Duty to the Engineering Journals 223
  Teaching Construction Methods........ 337
  Treatises; Three Volumes........ 53
  Work, Time Required for........ 75
Engineers:
  And the Politician 399
  Attitude of Employed to Unemployed.. 291
  Caution in Expressing Opinions........ 268
  Code of Ethics for Western Society... 255
  Construction, need of........ 276
  Co-operation; Opportunity to Further. 151
  County Highway, Office System for... 438
  Creatures of Habit........ 152
  Cultivating Mayors 424
  Drainage, Compensation of........ 242
  Drainage; Small Compensation........ 152
  Executive 152
  Expert Witnesses 229
  French, Killed in Battle........ 153
  From a Newspaper Standpoint........ 97
  Interest in Activities of the Individual 337
  Looking Abroad for Opportunities..... 312
  Medal for Inconspicuous Public Service 125
  Motives of, in Specification Writing... 225
  Not Readers 152
  Provinciality of 268
  Public Duty; a Clergyman's Opinion... 153
  Public Speaking for........125, 223
  Public Uneducation Regarding........ 153
  Relations Between Contractor and..... 312
  Scientific Farmers 511
  Separate Organization for Publicity Work Inadvisable........ 108
  Trend Toward Self-improvement........ 312
  Withholding the Word of Commendation 381
Engines of War, American Invention of. 125
Equipment, Reserve or Standby........ 2
Excavating:
  Science in 151
  Effective Pumping Unit for........ 404
  Non-freezing Explosives for........ 387
  Quarrying a Large Granite Block..... 529
  Removing Rock from Deep Manhole... 530
  Steam Shovel Records on Large Cut.. 592
  Steam Shovel Road Grading........ 531
  Steam Shovel, Road Work........ 527
  Tipple for Removing........ 409
  Trench, Handling Water Pipes in..... 288
  Turntable for Removing........ 409
Excavators:
  Dragline Scraper for Drainage Ditches 116
  Straddle Ditch Drainage........ 63
  Templet for Ditch Excavation........ 128
  Wheel Type for Drainage Ditching.... 89
Expert, Definition of........ 292
Explosives:
  High Price of........ 574
  Non-freezing 387
Extra Work, Allowance for........ 587

F

Fair Return; Rate of, for Water Works Properties 99
Fence Posts:
  Concrete, Cost of........ 571
  Reinforced Concrete, Manufacture of.. 411
Ferry Transfer Bridge, Method and Cost of Moving 261
Field Engineering 72
Filing Systems; Municipal Engineering Records 96
Filter:
  Alum; Effects on Brass Pipe........ 398
  Washing; Rapid Sand, New Jersey Experience 47
Firemen; Water Pumping Stations, Lectures to 28, 294
Flood Control:
  Dayton, O., Plans for........ 382
  Legislation in Congress........ 485
Flood:
  Mitigation; Evaluating the Benefits... 98
  Protection; Miami Valley........ 547
Foreign Exporters, Advantages Enjoyed by 461
Forms:
  Concrete; Design and Construction..209, 257
  Concrete, the Design of........ 199
  Unit Steel for Roads........ 26
  Wire Tightening for Walls........ 204
Foundations:
  Lincoln Memorial, Washington........ 354
  Pile, Baltimore Pier........ 179
  Pile Tests 18
  Union National Bank Building........ 389
Freight Cars, Life of Steel........ 381

G

Gas Holder; Releveling, Methods of..... 465
Gas Mains:
  Construction 441
  Construction Across River........ 441
Gas Safety Code........ 68
Geological Survey Work, 1915........ 50
Grain Elevator:
  New Orleans 12

Grain Elevator (Continued).
- Failure of ... 66, 110
- Righting a Tilted ... 66, 110

Gravel Hauling, Comparison of Team and Tractor ... 327
Groundwater in Sewers, Estimating ... 367
Grout:
- Track Foundation ... 334
- Dam Cutoff Wall ... 412
- Lining Steel Syphons ... 416
- Machine for Astoria Tunnel ... 470
- Metal for Lock Foundation ... 180
- Stone Track Foundation ... 129

Grubbing; Methods, Kensico Reservoir ... 56

H

Harbor Pollution; New York, Remedy of 492
Hawsers, Comparative Strength of Manila and Wire ... 407
Heating; Central Station in Thirteen Minnesota Cities ... 356
Highway Commission, Work of Iowa ... 159
Highway Department:
- Oklahoma; Engineering Work ... 201
- Overhead Expenses; Pennsylvania ... 472

Highways, Paved and National Defense. 379
Horse Watering Fountain ... 409
Hydrated Lime:
- Addition to Concrete for Road Work ... 225
- Tests on, for Road Work ... 206

Hydraulic Equivalents, Convenient ... 234
Hypochlorite Fumes; Corrosion to Machinery ... 11
Hypochlorite Plant, Emergency ... 414

I

Illinois Waterway, Decision of Chief of Engineers Against ... 253
Imhoff Tanks; New Jersey Experience ... 19
Improved Block and Fall ... 588
Industrial Town; Iroquois Falls, Ontario. 524
Infiltration Gallery, Defense of ... 215
Ink:
- Condensed for Camp Use ... 589
- Versus Water Color Paint ... 422

Inventions and Patents ... 74
Inverted Syphon, Reinforced Concrete Construction of ... 247
Investigating Committees, Legislative ... 511
Iowa State Drainage Association ... 190
Irrigation:
- Accounting Method ... 269
- Canal Slope Trimmer ... 415
- Engineer, Duty of ... 253
- Laterals; Concrete Lining Costs ... 352
- Los Angeles Aqueduct System ... 82
- Losses of Water by Seepage from Canals ... 544
- Practice and Engineering ... 70

Problems ... 103, 199
- Projects in Oregon ... 496
- Pumping Water for ... 489
- Structures, Comparison of Wood and Concrete for ... 340
- System, Reeves County, Tex ... 504
- Weir Box ... 414
- Work, Classification of Expenditures for ... 201

J, K, L

Joint Cost; Prorating Theory ... 2, 9
Labor and Capital, Co-operation Between ... 176
Labor Shortage, Common ... 511
Levee Construction:
- Cableways for ... 528
- Slackline Cableway Work ... 529

Lights:
- Contractor's Flare ... 26
- Flare, Using Carbide Cakes ... 26
- Nitrogen-filled Incandescent ... 305

Lincoln Memorial, Foundations for ... 354
Liquid Chlorine:
- Determining Point of Application ... 487
- Plant, San Jose, Cal ... 506

Lock and Dam Work:
- Example of Delayed ... 486
- Government, Failure of Contractors in 461
- Government, Blame for Failure of Contractors on ... 535

Locomotives:
- Electric, Chicago, Milwaukee & St. Paul Railroad ... 511
- Electric, First Used ... 413

Lumber Specifications, Uniform and Definite ... 200

M

Macadam Screening Cart ... 132
Machine, Tree Planting by ... 590
Magnetic Iron Corner Monuments ... 569
Mains, Foul Water ... 442
Manholes, Removing Rock from Deep ... 530
Manual of Surveying for Field and Office 73
Manufacturers, Keeping Up with ... 124
Marine Railway Proposed for Fox River. 411
Masonry as Applied to Civil Engineering 74
Materials of Construction ... 73
Mayor: Cultivation by the Engineer ... 424
Measuring Flowing Water; Practical Methods ... 536
Meterage:
- Practice, South Bend, Ind ... 6
- Montana Regulations ... 49

Meters:
- Record Cards ... 6
- Setting, Using Motor Cars for ... 504
- Testing Charges ... 7
- Water, Experience at Iowa Falls ... 434

Michigan Agricultural College; Continuation of Engineering Instruction ... 290
Military Engineering, Chicago Joint Committee on ... 330
Mill Buildings; Portable Steel; Erection Equipment ... 413
Monthly Magazine Issues of Engineering and Contracting ... 509
Mortar Mixing Box, Steel ... 299
Mosquito Extermination; Experience at Philadelphia ... 372
Motion Pictures, Engineering Advertising and Selling by ... 75
Motor Cars for Field Work ... 504
Motor Truck:
- Advertising for Contractors ... 289
- Example of Uneconomic Use ... 510
- Gas Accident Emergency ... 544
- Road Construction ... 22
- Road Construction; Proof Against ... 444
- Service in New York City Park Departments ... 550
- Six-Wheel for Long Loads ... 25
- Tires; Life of, Abuses That Shorten ... 366
- Winch Equipment for Tractor Service. 297

Municipal Improvements; Standard Units for Comparison ... 518
Municipal Information, City Co-operation to Secure ... 485

N, O

National Conference on Concrete Road Building; Resolutions ... 191
National Defense, Relation of Paved Roads to ... 387
Needle; Penetration, for Testing Bituminous Materials ... 363
North Carolina Road Institute ... 219
Oil Barrel; Dynamite Thaw Kettle ... 91
Oil Engine Pumping Data ... 217
Oil for Sand and Oil Roads ... 153
Oil Furnace:
- Drilled Steel Reheating ... 109
- With Preheating Features ... 109

Office Building Names; Use for Addresses 224
Office Methods for Small Contracting Business ... 317
Office System for County Highway Engineers ... 438
Overhead Expenses, Pennsylvania Highway Department ... 472
Oxy-acetylene:
- Welding Outfit ... 185
- Welding; Corroded Pipe ... 416

P

Paint, Life of ... 338
Panama Canal:
- Geology of Slides ... 269
- Lighting System for ... 398

Parks:
- Cost of Spading and Raking ... 230
- Preparing and Seeding, Cost of ... 211

Paved Highways and National Defense. 387
Pavement Base:
- Method of Anchoring to Curb ... 507
- Reclaiming Stone from Old Macadam for ... 132
- Thickness; Government Investigation. 63
- Artificial Foundations for ... 449
- Block; Applying Bituminous Filler ... 166
- Block; Removing by Plowing ... 531
- Brick; Analysis of Monolithic ... 322
- Brick; Clean Brick Essential for Perfect Grouting ... 262
- Brick; Recent Advancement in Construction ... 93
- Brick, Sand Requirements for ... 296
- Brick, Strength of Undermined ... 589
- Comparative Values of Various ... 481
- Concrete; Contract Prices ... 126
- Concrete, Cost of Removing ... 410
- Concrete; Detailed Cost ... 127
- Concrete; Emphasizing the Finishing Process ... 415
- Concrete, Experience with Bitumen Carpeted ... 363
- Concrete, Tonawanda, N. Y ... 125
- Construction; Concrete, Methods of ... 125
- Construction; Queensboro Bridge, New York ... 591
- Cushion ... 57, 93
- Foundations; Uniformity Required ... 453
- Grouting ... 262
- Header Construction for, Houston, Tex. 408
- Plow; Cleveland Ry. Co ... 531
- Sheet asphalt and brick, Cost of ... 495

Paving Brick; Marking for identification in Tests ... 80
- Rattler Test for ... 198
- Rattler Test, Unusual Application ... 329

Paving Street Railway Tracks, Peoria, Ill. ... 503
Pile Driver Barge, Cost of Constructing. 406
Piles; Device for Sawing Under Water ... 405
- Closely Spaced for Stack Foundation. 507
- Combination Concrete and Timber ... 470
- Concrete; Handling Tops of ... 405
- Concrete Cylinder ... 550
- Concrete with Socket Bottom ... 470
- Formulas for Determining Pressure on. 245
- Making Bottom for Before Driving ... 179
- Method of Bracing Below Water Level. 414
- Tests ... 18

Pipe:
- Cast iron; Method of laying submerged 499
- Repairing Injured by Oxyacetylene Welder ... 416
- Rifled, Origination of ... 511
- Riveted Steel Maintenance, Portland, Ore. ... 367

Pneumatic Tamping; Sewer Trenches ... 530
Political Outlook ... 574
Politician; Handling of ... 462
Portable Storehouse for Cement ... 483
Positions Vacant; Free Publication of Advertisements ... 151
Power Plants:
- Diesel Engine, Palo Alto, Cal ... 44
- Efficiency in Public Utility ... 162
- Hydro-electric, Arkansas ... 594

Practical Surveying ... 74
Practical Track Work ... 72
Prices:
- And Wages; Rising, Danger to Contractors ... 123
- High; Effect on Construction Operations ... 444
- Steel Products ... 219

Problems in Theory and Design of Structures ... 73
Public Improvements; Forces that Instigate ... 225
Public Schools; Water Consumption at ... 96
Public Utility Commissions; Neutrality of ... 243
Public Works Construction; at End of War ... 443
Pumping:
- Costs of Drainage ... 94
- Effective Unit for Excavation Work ... 404
- Electric, Memphis, Tenn ... 349
- Machinery; Corrosion by Hypochlorite Fumes ... 11
- Plants; Drainage, Expert Operations ... 65
- Sewage by Electricity ... 2, 16, 18
- Station; Sewage, Boston ... 18
- Water; Diesel Engine, Palo Alto, Cal ... 44
- Water; Oil Engines, Cost and Test Data ... 217
- Water; South Bend, Ind ... 4

Pumps:
- Centrifugal; Steam-turbine Driven ... 376
- Deep Well, Gas Engine Driven ... 495
- Duty Record of Centrifugal ... 376
- Pressure for Concrete road Construction ... 348
- Road Oil Special ... 576
- Wills; for Deep Wells ... 578

Purchasing ... 73

Q

Quarrying a 225-ton Granite Block ... 529
- Rockland Lake, New York ... 512

R

Rails:
- Price of ... 338
- Railway; Shoe for Snaking ... 589

Railway:
- Bridge and Building Department Efficiency ... 39
- Congestion ... 290
- Field Manual for Engineers ... 73
- Maintenance Engineering ... 74
- Roadbeds; Methods of Draining ... 173
- Swamp Location and Construction ... 275
- Track Ballasting by Contract ... 269

Rapid Transit Subway, Chicago; Plans. 51
Ration List; Tropical ... 410
Reading a Habit ... 152
Records:
- Construction Changes ... 3
- Cost; Progress for Sewer Construction. 64
- Filing Engineering; Method of ... 96
- Form for Road Work ... 81

Reinforced Concrete:
- Arches; Choosing Neutral Axes for ... 455
- Arch Bridge, Lawrence, Kans ... 35
- Arch Bridge, Lyons Falls, N. Y ... 160
- Arch Bridge, Sweden ... 343, 457
- Conduit ... 238
- Fence Posts Manufacture ... 411
- Grain Elevators ... 13, 66, 110
- Hotel; Alberta, Can ... 299
- Hotel Traymore, Atlantic City ... 14
- Intercepting Drain, Fall River, Mass ... 60
- Inverted Syphon Construction ... 247
- Pumping Station ... 19
- Reservoir, Austin, Texas ... 186
- Reservoir Construction ... 522
- Reservoir, Salem, Mass ... 127
- Retaining Wall Construction ... 207
- Sewage Treatment Plant ... 130
- Storm Water Storage Tank ... 90
- Substructure; Savannah Steamship Terminal ... 11
- Viaduct; Portland, Me ... 368

Reinforcement; Strength of Splice Joints. 578
Relief Map; Construction of ... 480
Reserve Equipment; Economies of ... 2
Reservoir:
- Concrete; Contract Prices ... 128
- Concrete; Folly Hill, Salem, Mass. ... 127
- Design and Cost of Improvement ... 262
- Home Machine for Building Embankment ... 506
- Reinforced Concrete; Austin, Tex ... 186
- Reinforced Concrete; Circular ... 522
- Planting Small Trees at ... 415
- Storm Flow Through ... 370

Retaining Wall; Reinforced Concrete ... 207
River and Harbor Legislation; How It Is Being Fought ... 143
River Improvements:
- Board, Mat and Brush Mattress Bank Protection ... 551
- Lumber Mat Bank Protection ... 526
- Shore Protection; Placing Rock by Derrick Boat ... 526
- Winter Dam Construction; Mississippi River ... 251

Rivers and Harbors:
- Appropriation; Attitude of Engineers and Contractors Toward ... 175
- Permanent Commission to Apportion Expenditures ... 225

Road Appropriation; $85,000,000 Assured. 553
Road Construction:
- Alabama, in 1915 ... 540
- Baltimore Canvass Cement Storehouses ... 404
- Bonding Gravel for ... 471

- Road Construction (Continued).
  - Brick, Modern Methods 567
  - Concrete; Approximate Plant for.......... 575
  - Concrete; Gang Organization for.......... 177
  - Concrete; Good Practice in.......... 191
  - Concrete, Details and Methods.......... 445
  - Concrete; Easton-Allentown, Pa.......... 466
  - Concrete; Organization of Concreting Gangs 251
  - Concrete, Philadelphia, Pa.......... 390
  - Concrete Tests 569
  - Concrete, Water Supply for.......... 425
  - Concrete; Well Water for.......... 473
  - Concreting Methods, New York State.. 385
  - Concreting, Organization of Concreting Gangs 463
  - Contract and Day Labor; Choice Between 286
  - Convict Labor 494
  - Correspondence Course in.......... 199
  - Cost of Engineering Supervision.......... 451
  - Cost of Provision for Traffic.......... 400
  - Detour Sign 59
  - Form for Recording Time of Machinery 81
  - Grading with Steam Shovel.......... 531
  - Gravel Hauling Costs.......... 23
  - Gravel; New Hampshire 266
  - Gravel; Northern Michigan.......... 577
  - Gravel; Volume Required 23
  - Hauling Materials by Portable Railway 185
  - Iowa 572
  - Materials; Costs of Laboratory Tests.. 473
  - Merits and Demerits of Contract System 298
  - Motor Truck Proof 177
  - Motor Truck Proof.......... 444
  - Motor Truck Hauling.......... 22
  - Opening of Season, 1916.......... 311
  - Provision for Traffic During.......... 216
  - Sand and Oil, by Layer Method.......... 153
  - Steam Shovel Excavation.......... 527
  - Steam Shovel Excavation for.......... 570
  - Subgrade Preparation; Processes Included in 423
  - Swamps 44
  - Warren County, Ky.......... 459
  - Washington, by Convict Labor.......... 494
- Road Dragging:
  - Minnesota 158
  - Minnesota Practice 158
- Road Drainage, Instance Where Consideration Is Warranted.......... 462
- Road Engineering Supervision Costs 461
- Road Improvement; Educational Movement by Motor Truck Makers.... 99
- Road Maintenance:
  - Concrete; Costs in Illinois.......... 196
  - Concrete; Methods and Costs in Ohio. 435
  - Concrete; Using Portable Heating Kettle and Auto Truck.......... 196
  - Concrete; Wayne County, Michigan.. 24
  - Cost; Comments on.......... 292
  - Costs, New York State.......... 246
  - Dragging in Minnesota.......... 158
  - Forms and Instructions for.......... 539
  - Gravel; New Hampshire Methods.... 241
  - Patrol and Gang System, Maryland... 352
  - Steele County, Minn.......... 592
- Road Materials:
  - Bituminous, Specifications for.......... 499
  - Cataloging by States 123
  - Hauling; Toronto-Hamilton Highway.. 185
  - Non-Bituminous; Standard Analysis and Tests 114
  - Relation between Hardness of and Toughness of Rock.......... 275
  - Sand and Oil Roads.......... 153
- Road Routes; Method of Marking, New Hampshire 405
- Road School:
  - Purpose and Value 98
  - University of Michigan.......... 23
  - Wisconsin Highway Commission 24
- Road Work; Forms of Contracts for, Minnesota Experience 236
- Road Supervision:
  - Automobile Costs in.......... 221
  - Cost of Operating Automobile.......... 414
- Road System:
  - A Notable County.......... 444
  - French; Proposed for New Jersey.... 557
- Roads:
  - Asphaltic Macadam Construction Features, Massachusetts 558
  - Bituminous Macadam; Methods of Resurfacing 128
  - Concrete; Clay Curing Blankets.......... 399
  - Concrete; Cleaning for Bituminous Covering 399
  - Concrete; Coleman-Dupont 314
  - Concrete; Concreting Gang Organization 177
  - Concrete; Costs in United States.......... 330
  - Concrete; Costs of in Illinois.......... 108
  - Concrete; Handling Bulk Cement.......... 415
  - Concrete, Joint Construction.......... 548
  - Concrete; Notable Example of.......... 311
  - Concrete; Operated for Measuring Wear 234
  - Concrete, Cost of, Illinois.......... 571
  - Concrete; Experimental, Reinforced .. 576
  - Concrete, Foundation Construction for. 398
  - Concrete, Pressure Pump for Water Supply 318
  - Concrete; Proper Location of Reinforcement 401
  - Concrete; Proportioning Concrete.......... 41
  - Concrete; Safe Period for Admitting Traffic to 401
  - Concrete; Standard Cost Form for.... 326
  - Concrete; Subgrade Construction for.. 325
  - Concrete; Tamper and Strike Board for. 321
  - Cost of Hauling Gravel for.......... 327
  - Expansion Joint Material for.......... 325
  - Fayette County, Kentucky.......... 22
  - Illinois; Situation in 324
  - Kentucky; Organization for State Aid Construction 324
- Roads (Continued).
  - Machinery; Fayette County, Kentucky.. 22
  - Concrete; Study of Cracks in.......... 357
  - Concrete; Water Supply from Wells.. 570
  - Construction Costs 260
  - Earth; Cost of Surface Oiling.......... 85
  - Federal Aid for 122
  - Federal Aid Law 280
  - Gravel Construction by Feather Edge Method 439
  - Gravel; Cost in Clay County, Iowa.... 460
  - Improved; Relation of School Attendance to 269
  - Increase in State Aid Expenditure.... 269
  - Macadam; Oiled, Slipperiness of.......... 161
  - Macadam; putting in the Permanent Class 330
  - Macadam; Remedying Slipperiness of.. 161
  - Macadam; Repairing Macadam with Traction Hauling Outfit.......... 580
  - Macadam, Sand Tar Coating to Prevent Slipperiness 227
  - North Carolina; Plans and Accomplishments 317
  - North Dakota; Costs and Conditions of Construction 321
  - Pennsylvania; Maintenance Work in 1916 316
  - New York; Present Status of Earlier. 543
  - Road Construction; Concrete, Minor Cost Items 380
  - Sections; Economic Analysis.......... 43
  - Slipperiness, Remedying 161
  - Sub-grade Preparation 359
  - Signs; Detour 59
  - Unit Steel Form.......... 26
  - Waterbound Macadam; Reconstruction in Rhode Island 314
- Rock Drilling; 12 Years' Progress in.... 510
- Rock Excavation; Quarrying at Rockland Lake 512
- Rock Mastic; American Substitute for.. 483
- Rock; Relation between Toughness and Hardness for Road Building.......... 275
- Roller Conveyors Used in Construction Work 278
- Rolling Mills; Minnesota Steel Co.......... 155

S

- Safety Engineering Applied to Scaffolds. 74
- Sand-Bin; Removing by Gondola Car... 412
- Sand; Distribution of Vertical Pressure Through 53, 306
- Sanitary Survey; Indiana Summer Resorts 276
- Scaffolds; Safety Device for.......... 158
- Scientific Management and Legislation; Relating to 359
- Sea Water; Concrete Characteristics to Resist 469
- Septic Tank:
  - Cost of Remodeling, Lake Forest, Ill.. 284
  - National Protective League.......... 281
  - Process; Advertisement of.......... 244
- Sewage; Application to Contact Beds.... 19
- Sewage Disposal Development for Los Angeles, Cal. 491
- Sewage:
  - Pumping; Electric 2, 16, 18
  - Pumping Station; Combined Traffic Signal and 590
- Sewage Treatment:
  - Activated Sludge Experiments, Milwaukee, Wis. 104
  - Activated Sludge Process.208, 235, 379, 386
  - Activated Sludge Process; Chicago Stock Yards 388
  - Activated Sludge Process; Success of. 97
  - Artificial Means; General Review.......... 581
  - Contact; Beds 19
  - Experiments with Small 420
  - Imhoff Tanks 19
  - Intermittent Filtration 168
  - Plant; Cost in Illinois.......... 185
  - Plant Life Prolonged by Competent Operation 52
  - Plant; Pana, Ill. 130
  - Purification of Wastes from Woolen Goods 560
  - Septic Tank; Contest against.......... 216
  - Septic Tank; Lake Forest, Ill.......... 284
  - Trickling Filter; Pana, Ill.......... 130
  - Work for Cities on Boundary Waters.. 551
- Sewage Works Operators; State Associations of 339
- Sewerage; Application of Electricity..2, 16
- Sewer Construction:
  - Double Barrel 593
  - Cost Progress Recording 64
- Sewer:
  - Construction Plant, Electric 16
  - Storm, at Dayton, O.......... 491
  - Design; Estimating Quantity of Ground Water 367
  - Maintenance; Importance of Proper... 360
  - Materials; Choosing in Portland, Ore. 184
  - Pipe; Tests on Supporting Strength... 394
  - Report; Milwaukee, Wis.......... 290
  - Syphon; Failure to Operate, Causes for. 180
  - Asphalt Joints for Tile Pipe.......... 192
  - Combined and Storm Water; Features of Design 228
  - Concrete; Experience with 277
  - Concrete; South Bend, Ind.......... 137
  - Infiltration of Ground Water.......... 350
  - Salt Lake City 16
  - Tight Joints in 185
  - Tight Joints in Submerged.......... 143
  - Vitrified Clay Segment Block Construction 260
- Sidewalk; Grades at Street Intersections 346
- Sidewalks:
  - Design and Location; Aesthetic Considerations 336
  - Outfit for Roughing 543
- Shacks; Portable for Small Contract Work 473
- Shaft Lining:
  - Concrete 144
  - Concrete; Bisbee, Ariz.......... 148
  - Concrete; Brier Hill Mine.......... 145
  - Concrete; Chapin Mine, Michigan.......... 146
  - Concrete; Costs of.......... 144
  - Concrete; Dawson Mine, New Mexico. 147
  - Concrete; Kingdom Shaft, Globe, Ariz. 148
  - Concrete; Mine Shafts, Annabelle, W. Va. 145
  - Concrete; Mine Shaft at Tug River, W. Va. 144
  - Concrete; Negaunee Mine, Michigan.. 145
  - Concrete; Notable Article on.......... 123
  - Concrete; Palms Mine, Mich.......... 149
  - Concrete; Shaft Eight, Rondout Tunnel 144
  - Method of Sinking in Water Bearing Draft 405
- Sheet Piles; Pulling by Steam Hammer. 407
- Short Articles; Policy of Publication.... 399
- Snow; Melting with Asphalt Road Heater 413
- Snow Removal 368
- Soil Erosion; Method of Preventing.......... 548
- Soils; Distribution of Pressure Through. 229
- Soil:
  - Suppurating Power Studies.......... 52
- South Bend, Ind., Water Works.......... 3
- Southwestern Concrete Association.......... 559
- Specification Writing; Fairness and Definiteness in 236
- Stacks; Shooting Soot from.......... 506
- Standard Units; Comparing Municipal Improvements 518
- Standpipe; Corrugated Iron, Philippine Islands 336
- Steel Industry; Electric, Growth of.......... 76
- Steel Pipe; Maintenance of, Portland, Ore. 367
- Steel Pipe Manufacture; Cost of.......... 497
- Steel Plant; Minnesota Steel Co.......... 154
- Steel Products; Prices of, 1898-1915.......... 219
- Steel:
  - Rising Prices 123
  - Rust-Proofing 511
- Stevens Institute of Technology.......... 236
- Stone:
  - Determining Weight of in Vessels.549, 571
  - Drier and Heater.......... 557
  - Tracks; Shrinkage of 180
  - Weight of; Effect of Mortar on.......... 180
- Storage Filters; Design and Operation of Intermittent Sand 168
- Storm Flow Through Reservoir.......... 370
- Strawboard Waste Purification.......... 476
- Street Cleaning; Motor-driven Squeegee for 211
- Stream Flow:
  - Chemical Method of Gaging.......... 542
  - Records; Suggestion for Using.......... 576
- Stream Pollution; Essence of Laws Governing 301
- Street:
  - Cleaning, Cleveland, Ohio 20
  - Flushers, Two-Motor 122
  - Lighting; Incandescent Lamp, Nitrogen Filled 305
  - Sprinkling; Trucks for, Portland, Ore.. 497
- Streets; Standard Warning Signs, Portland, Ore. 187
- Sub-grade Preparation; Roads 359
- Subway Construction; Traffic Regulation Over 124
- Sun Spots and the Weather.......... 424
- Superintendent; the Day of 444
- Surveying:
  - Corner Monuments; Magnetic Iron.... 469
  - Mathematics of Vertical Curves.......... 523
- Standpipe; South Bend, Ind.......... 5
- Subway; Rapid Transit, Chicago.......... 51
- Surveying and Field Work.......... 74
- Swamp Road Construction 44
- Swimming Pool; Putty for Plugging Holes in 473
- Swing Bridge; Long Span Plate Girder.. 422
- Syphons; Method of Concrete Casing and Lining 416

T

- Tainter Gate Seat and Chain Connection for 507
- Tanks; Storm Water Storage, Toronto, Ont. 90
- Target for Determining Azimuth.......... 129
- Tar Painting Concrete to Resist High Velocities of Water.......... 56
- Technical Journals in Engineering Schools 28
- Temperature Stresses; Concrete Girders. 333
- Terminal; Steamship, at Savannah.......... 11
- Tests:
  - Effective Width of Bridge Slabs.......... 447
  - Standards for Non-Bituminous Road Materials 114
- Text Book of Geology.......... 60
- Theory, Presenting First Cost.......... 2, 9
- Thermometer; Centigrade Scale, Adoption as Standard.......... 100
- Tile:
  - Hollow; Use in Building Construction. 139
  - Strength of Hollow Walls.......... 139
- Timber:
  - Of Output of Treated, in 1915.......... 587
  - Tests of Bridge Stringers.......... 427
  - Use in Modern Structures.......... 243
  - Methods of Excavating Submerged.... 408
- Tipples for Removing Excavated Material 409
- Topics; Conversational, Two Unpopular. 176
- Toys; Pouplarizing Engineering by.......... 52
- Track:
  - Construction on Unstable Ground.......... 471
  - Foundation; Grouted 334
  - Street Railway; Grouted Stone.......... 129
- Tractor:
  - Caterpillar, for Clearing Brush.......... 527
  - Winch Equipped 297

Trade Wastes; Treatment of in Emscher District 372
Traffic Regulations; Street Subway Construction 124
Train Sheds; Railways; Canopy Type... 408
Travelers; Erection, Hell Gate Bridge.. 35
Tree Planting by Machine.......... 590
Tremies; Concrete Stopper for.......... 180
Trench:
  Backfiller, with Caterpillar Traction.. 346
  Making; a New Method of.......... 514
  Tamping; Pneumatic Rammer Methods. 530
Trestle for Distributing Ties on.......... 587
Trucking Freight; Bonus System for.... 569
Trucks; Combination Road Maintenance and Construction 495
Truss; Highway Bridge Loading.......... 92
Tunnel:
  Construction; Device for cooling Compressed Air 528
  Grouting Machine for.......... 470
  Cost of Driving Heading in Hard Rock 557
  Harlem River Four Track Subway.520, 545
  Lining, Concrete, Arminto, Wyoming.. 32
  Lining, Concrete by Compressed Air.. 29
  Lining, Concrete, Diana, Kentucky.... 32
  Lining, Concrete, Pneumatic Mixing and Placing 502
  Lining, Concrete, St. Louis Water Supply 29
  Lining, Concrete, Steam Jetted.......... 181
  Lining, Concrete, Sandy Ridge, Va.... 31
  Water Supply, Wilson Ave., Chicago.. 502
  Submerged Heading; Method of Breaking Through 431
Turntable for Excavated Materials.......... 409
Typhoid Germs; Carried for 29 Years... 442

V

Valuation:
  Rate of Fair Return on Waterworks. 99
  Waterworks Properties 9, 362
Valve Gear, Air Compressor 24
Valve Inserting Machine; Method and Cost of Using 507
Vertical Curves 523
Viaduct:
  Bloor St., Toronto.......... 280
  Reinforced Concrete, Danville, Ill.......... 134
  Reinforced Concrete, Portland, Me.... 368

W

Wagon Drilling Rigs for Heavy Excavation 472
Water:
  Boiling; Neglect of Instructions.......... 313
  Consumption; Checking Excessive, Framingham, Mass.......... 283
  Consumption; Checking Excessive, Gardner, Mass. 296
  Consumption; Public Schools, Hartford, Conn. 96
  Filtration; Aesthetics an Asset.......... 553
  Main Construction; Small Steel, Philippine Islands 187
  Mains; Depth of, to Prevent Freezing. 167

Water (Continued).
  Mains; Methods and Costs of Testing, Hartford, Conn.......... 80
  Main Extension, handling projects, Washington, D. C.......... 454
  Main; Lowering Under Pressure.......... 412
  Measuring Flowing; Practical Methods 536, 576
  Meters; Cost of Operating and Maintaining 180
  Meters; Preparing Consumers for Introduction of 250
  Pipes; Capacity of Old Cast Iron.......... 282
  Pipe; Leadite Joints for.......... 207
  Pipes; Rules for Handling in Excavation 288
  Pipe; Special; What Is a Special?.206, 225
  Power Engineering (Book).......... 60
  Power; Railway Electrification and.... 456
  Power; Race between Steam and.......... 551
  Purification; Bubbly Creek, Chicago.... 137
  Purification; Carbon Dioxide Removal. 47
  Purification; Emergency Hypochlorite Plant 414
  Purification; Iron Removal and Softening Plant, Springfield, Ill.......... 455
  Purification; Special Removal by Lime 11
  Purification; Liquid Chlorine, Determining Point of Application.......... 487
  Purification; Liquid Chlorine Plant, San Jose, Cal. 506
  Purification; Maryland Experiences in Disinfecting 396
  Purification; Milwaukee, Wis., Experience in Chlorination 430
  Purification Plants and Their Operation 71
  Purification; Plant Life Prolonged by Competent Operation 52
  Purification; Removing Larvae from.. 136
  Purification; Special Features, Indiana Plants 309
  Purification; Sterilization, Chicago.... 398
  Purification; Storage, Essential Elements 304
  Purification; Strawboard Waste.......... 476
  Proofing Putty for Plugging Seep Holes 473
  Rates; Princeton, Ind.......... 329
  Rates; South Bend, Ind.......... 8
  Rate; Unwise Lowering of at Columbus, O. 219
  Service; Decreasing Cost, Omaha, Nebr. 456
  Services; Effect of Frozen Sewer Lines. 167
  Service Pipes; Installation and Maintenance of 344
  Softening Plant; Bubbly Creek, Chicago 137
  Softening; Cost of, Hinsdale, Ill.......... 297
  Supply; Chlorination at Milwaukee.... 430
  Supply; Contaminated, Warnings Disregarded 200
  Supply; Larvae in, Champaign, Ill.... 136
  Supply; Meterage of, Miles City, Mont. 326
  Supply; Protection by Intercepting Drain 61

Water (Continued).
  Supplies; State Control of Maryland... 450
  Supply; Storm Storage Tank for.......... 90
  Tanks; Spherical.......... 68
  Tower; Ornamental, Kenmore, O.......... 335
  Waste Detector 555
  Waste Prevention on Railroads.. .. 590
  Waste; Method of Measuring, Newfoundland 555
  Works; Bath, Maine, Purchase of, by City 250
  Works Data; Census Bureau.... 424
  Works; Design and Construction.......... 182
  Works; Distribution, South Bend, Ind. 5
  Works Efficiency; Increasing Under City Management 446
  Works; Experience in Operation in Freezing Weather 437
  Works; Fire Prevention Committee Reports on 511
  Works; Foreman's Plat, Method of Making 451
  Works; Infiltration Gallery, a Defense of 215
  Works Magazine; Announcement of Publication 485
  Works Maintenance; Economies Effected, Baltimore, Md.......... 221
  Works Maintenance; South Bend, Ind.. 3
  Works Operation; Montana Regulations 48
  Works Operation; South Bend, Ind... 3
  Works; Plant Operation, Suggestions for 169
  Works; Profitable in Wisconsin.......... 442
  Works Publicity; Campaign at Terre Haute, Ind. 509
  Works Pumping; South Bend, Ind.... 4
  Works Records; South Bend, Ind.......... 6
  Works Reports; Innovation Deserving Imitation 462
  Works Reservoirs; Grubbing Methods Catskill Water Supply 56
  Works; Valuation of 9, 99, 362
  Works; Victoria, B. C.......... 182
  Works; Well for, Dallas, Tex.......... 541
Weir Box; Irrigation 414
Wells:
  Conducting and Driving Methods.......... 85
  Drill; Loosening Jammed by Blasting.. 180
  Drilling; Cost of.......... 570
  Electric Pumping, Memphis, Tenn..... 349
  Relation of River Stage to Water Level in 242
  Units at Lincoln, Nebr.......... 505
  Waterworks; Cementation Method.... 541
Wheeled Scraper; Inventor of.......... 125
Winter Work; Engineers' Objections to.. 75
Wood; Definition of Knots in.......... 571
  Stave Pipe; Breaks in.......... 197
  Stave Pipe Line; Seattle, Causes of Recent Breaks 197
Woolen Goods Waste; Purification of.... 560
Warning Signs; Portland, Ore., Street.. 187

Y

Young Engineers; An Opportunity for... 469

AUTHOR INDEX

A

Acheson, W. M., 385; Acton, R. W., 236, 286, 298; Allaire, Alexander, 66, 110, Allison, R. H., 242; Amsbary, F. C., 136; Ashton, Ernest, 206.

B

Barrows, H. K., 60; Base, J. F., 305; Bates, S. E., 132; Beardsley, J. W., 103; Becker, A. J., 410; Bee, Chas. E., 269; Benedict, R. R., 128, Bennett, W. A., 64; Bilger, H. E., 439; Blanchard, M. D., 173; Bliss, J. W., 321; Bohmann, H. P., 430; Bond, P. S., 387; Borden, H. P., 196; Borbek, R. J., 225, 557; Breed, H. E., 260, 262, 296; Brosman, Chas., 162; Brown, H. P., 181; Burch, A. N., 352; Byxbee, J. F., 41.

C

Campbell, N. N., 284; Cameron, W. A., 90; Caplan, David, 101; Carpenter, C. V., 414; Carse, J. H., 91; Cassidy, J. Ed., 225, 403; Chamberlain, M. E., 336; Chapman, N. J., 527; Chase, Charles P., 350; Cobb, C. M., 317; Cobb, Lamar, 451; Compton, R. K., 331, Comstock, A. F., 125; Connell, Wm. H., 368, 372; Copeland, W. R., 386; Corthell, Elmer L., 462; Crohurst, H. R., 560; Crondell, J. S., 166; Crosby, W. W., 41, 449, 453; Crump, M. H., 459.

D

Daniels, F. E., 19, 17; Davies, J. V., 470; Diamond, F. L., 179; Diggs, John C., 309; Doerr, Paul W., 505; Dorr, E. S., 18; Drayer, C. E., 303; Drucker, M. A., 579; Durham, C. W., 251.

E

Eddy, Harrison P., 581; Egan, J. M., 260; Enger, M. E., 53; Everett, F. E., 241, 266.

F

Fallis, W. S., 317; Farrington, W. R., 153; Fay, F. H., 238; Ferriss, H. R., 213, 237; Fleming, R., 403; Ford, A. H., 305; Frank, Leslie C., 420; Fry, Albert S., 370; Furber, P. P., 204.

G

Gillette, H. P., 9, 99, 362, 463; Gilliland, A. H., 325; Goldbeck, A. T., 234, 447; Goldenstar, A. L., 262; Graves, W. E., 137; Green, P. E., 192; Greenough, M. B., 57, 322; Gwinn, Dow R., 500.

H

Habermeyer, G. C., 293; Hadley, F. A., 170; Hall, W. R. D., 316; Hanna, G. C., 20, 357; Harding, S. T., 340; Hardman, R. C., 410; Harris, F. W., 43, 136; Harrison, B. P., 161; Hartley, C. M., 530; Haskins, C. A., 242; Hatton, T. C., 104, 235; Hay, W. W., 299; Heinly, B. A., 82; Hill, James J., Railroad President, 533; Hoff, Olaf, 520; Hogarth, George, 373; Hommon, Harry B., 476; Hoover, H. C., 125; Hubbard, P., 275; Hyde, C. G., 304.

J

James, E. W., 221; Jefferson, Thomas, City Plumber, 28; Jennings, C. A., 137; Jettyhead, concrete construction, 138; Johnson, W. S., 127; Jones, W. D., 406; Jordan, Leonard C., 523.

K

Kelly, E. W., 262; Kilpatrick, J. D., 85; King, F. B., 276; Kipp, O. L., 327; Knowles, C. R., 217.

L

Leavitt, A. H., 366; Legreid, H. N., 438; Lenderink, A., 96; Longley, Francis F., 487; Lyndon, L., 186.

M

Mann, O. H., 81; Marr, W. W., 324; Martin, A. E., 207; Maury, D. H., 522; Maxwell, W. D., 283; McCullough, Ernest, 382; Mendenhall, B. W., 16; Moorehouse, A. D., 172; Morgan, Arthur E., 382; Morland, J. H., 158; Morse, Robt. E., 396, 450; Murphy, R. E., 431; Myers, E. L., 541.

N

Newell, F. H., 201; Nichols, C. G., 324; Nordell, C. H., 367.

O

Osgood, M., 363.

P

Pagon, W. W., 469; Patterson, T. W., 314; Paul, C. H., 56; Paul, F. T., 531; Perkins, F. C., 470, 499, 590; Perkins, W. C., 93; Pickles, J. L., 275; Piepmeier, B. H., 85; Pierce, D. T., 330, 483; Pierce, F. G., 216; Post, R. E., 529; Potter, Alexander, 215; Pritchard, F. P., 363; Pruett, G. C., 326, 437.

R

Rear, G. W., 39; Raschig, F. L., 263; Reed-Lewis, W. J. D., 414; Reeve, C. S., 363; ReQua, E. M., 481; Rice, L. M., 253; Rice, P. D., 506; Roman, F. L., 329; Rust, C. H., 182.

S

Scheson, W. M., 398; Schlick, N. J., 394; Schmeer, Louis, 489; Sherman, L. R. K., 301; Sherwin, R. A., 209; Sherwin, R. A., 231; Sherwin, R. A., 257; Shirley, H. G., 352; Smith, Albert, 375; Smith E. B., 447; Smith, F. S., 117; Smith, Vernon H., 403; Small, R. A., 142; Spencer, E. S., 228; Stanfield, A. C., 130; Sutton, C. R., 441.

T

Taylor, F. S., 186; Terrell, R. C., 324; Thompson, J. B., 158; Thompson, S. E., 220; Thurston, E. T., 109; Tilton, E. G., 406; Toyne, John W., 169.

U

Uhler, Wm. D., 466; Upham, Charles, 314.

V

Vandevanter, Elliott, 474; Van Scoyoc, H. S., 185; Veatch, N. T., 236.

W

Wellington, A. M., Railroad Locator, 533; Weston, A. D., 560; Weyher, John E., ..; Whittemore, G. F., 138; Williams, C. B., 297; Wilson, John, 346; Winsor, G. A., 56; Wisler, C. O., 536; Wolf, Albert M., 457; Woodson, J. B., 473; Woodward, G. M., 65, 94; Worrell, J. C., 473.

Y

Yarnell, D. L., 63, 89, 116, 120; Young, C. C., 242.

Engineering and Contracting

Devoted to the Economics of Civil Engineering Design
and to Methods and Cost of Construction

EDITORS
H. P. Gillette C. S. Hill C. T. Murray S. C. Hadden C. W. Malcolm

Volume XLV. CHICAGO, ILL., JANUARY 5, 1916 Number 1

TEN-YEAR ANNIVERSARY OF "ENGINEERING AND CONTRACTING."

This issue of "Engineering and Contracting" comes to its readers with a larger page, and in larger type and bearing many other modest embellishments to appearance. The journal today enters upon its eleventh year. During its life it has absorbed three engineering and contracting periodicals. With each acquisition changes have been made, but till now the need and a suitable occasion for aesthetic reconstruction have not conjoined. With the new and better appearing paper we shall provide a more serviceable and technically valuable paper.

The past ten years have been subnormal in the construction world, but there are many reasons for believing that the next decade will more than make up for the business depressions of the past. The panic of 1907 scarcely began to wear itself out when the activities of many railway and utility commissions served to frighten capital and thus to restrict work in engineering fields. Even yet this influence is having an effect, but the pendulum seems to be swinging back.

The election of a "free trade" President and Congress in 1912 gave still another jolt to many industries, the full effect of which had not been reached when the great war broke upon the world in the memorable summer of 1914.

So, within a space of ten years, three great events had served to unsettle financial conditions in America. A fourth great event has occurred that is having an opposite effect. We refer to the passage of the "Federal Reserve" system of banking. This affords an insurance against "money panics" and has doubtless been one of the most important factors in renewing the confidence that the war had shaken.

All men of vision are agreed that America has entered another of its wonder-working eras.

EDITORIAL PLANS OF ENGINEERING AND CONTRACTING FOR 1916.

The year just passed has not been good to engineers and builders of engineering works. Every engineer and contractor knows this even though it may not have been his personal misfortune to have suffered diminution of opportunity and income. Also all know the main causes for the year's lack of engineering employment; to rehearse them serves no purpose even were it not a repetition of which everyone has grown weary. Yet as the year drew to an end evidence appeared that the bottom of the valley had been reached and that our steps were set on the up-grade that reaches to higher engineering prosperity. We have said our steps, purposely, for it is the prosperous activity of the engineer and contractor that makes prosperity for the engineering journal. To foretell then the nature and extent of improved service that Engineering and Contracting will render its readers during 1916 is about as uncertain a thing as it is to prophesy the degree of prosperity that will come to engineers and contractors in the same period. As our readers and advertisers have laid their plans for a better year so the editors have planned improved service in the columns of Engineering and Contracting.

The improvement in typographical appearance receives notice elsewhere. Here we speak of plans to improve the quality of the technical and news articles to be provided. Precise scheduling of articles is not possible. There will, however, be an increase in the number of short articles recording the constructive acts of Federal and State departments and commissions having direction of engineering works. Such bodies are the highway departments of the several States, the public service commissions, the State health boards and the Federal bureaus dealing with roads and drainage and irrigation and the tests of materials of construction.

Another provision for better service will be devotion of unusual attention to operating engineering, such as water works operation and operation of drainage and irrigation works. A representative article of this kind describing water works operating methods is published in this issue. Appraisal and valuation practice and principles will receive that adequate discussion which in the past has made this journal the exception in this field among civil engineering papers. This issue furnishes an example of this character of article also.

The distinctive feature of Engineering and Contracting has, from the inception of the publication, been articles on methods and costs of engineering construction. In the early years of the paper these were about the only kind of articles published. As the paper grew, greater variety was introduced but always each year has witnessed the publication of an increased volume of data on construction methods and costs. The year 1916 will be no exception in this line of development. Among the methods and cost articles planned is a series reviewing the development of concrete construction methods. The data for these articles have been in process of collection and compilation for over a year, and the dozen or more articles written and planned are unique in the field of concrete construction engineering.

In line with these articles of practical utility and with the journal's policy of presenting always actual working data will be the careful and accurate presentation of working drawings of structures being built. No other civil engineering journal publishes drawings so fully dimensioned and detailed as those that have appeared during the past two years in Engineering and Contracting. This is the result of a definite policy which will be emphasized during 1916. We use the term policy advisedly. So set is the purpose to present complete drawings that where limitation is necessary it is exercised in the number of drawings used and not in incompleteness even in minor detail of the drawings published. These are, in all essential examples, so fully dimensioned and detailed that the shop and the field constructor can build from them with certainty.

The indication of our editorial plans is we think clear from what has been said. They are to emphasize those features of economics of engineering design and operation and of methods and costs of construction to the elucidation of which Engineering and Contracting has from its first issue devoted its efforts. Increased service to its readers in the recording of practical working information will then in 1916 be the purpose of the journal. This purpose will in no part of the paper be more emphasized than in the Current News pages. Both the contract news items and the larger articles on work planned for construction will be selected first of all for the opportunities for employment and sale of plant and materials that they offer the engineer, the contractor and the manufacturer.

A CORRECT GENERAL THEORY OF PRORATING JOINT COST.

A great deal has been written, particularly by mechanical engineers in reference to manufacturing, upon the subject of prorating or allocating joint costs. The subject has also been a favorite one for debate among accountants. There are so many theories of prorating joint costs that it may seem impracticable to produce a single theory of universal applicability.

Elsewhere in this issue Mr. Halbert P. Gillette, in an article on water works valuation, presents what he calls "the separate plant theory of prorating costs," and he claims for it universality of application. If the claim is well founded, the article mentioned will merit perusal by others than water works engineers and superintendents. In a subsequent article—not in his water works series—Mr. Gillette will give illustrations of the application of "the separate plant theory" to many classes of cost analysis, and he will go at greater length into an exposition of the fallacies of other theories of prorating costs.

Prices for products and for services are, in the long run, usually based on costs. Production on a large scale involves the use of plants, with resultant joint or indirect costs that form a large per cent of the total cost. Hence it becomes progressively more important to prorate joint costs properly. This has become very evident in railway and public utility fields during the past ten years of rate regulation. It will become equally evident eventually in every field of economic activity.

APPLICATION OF ELECTRICITY TO THE PROBLEMS OF SEWERAGE.

In both the construction and operation of sewerage systems electricity is playing an increasingly important part. Special attention is called to an article in the Sewerage and Sanitation section of this issue that illustrates and describes several types of electrically-operated machines as applied to sewer construction in Salt Lake City. The machinery described comprises electrically-driven centrifugal and double diaphragm pumps, and electrically-operated travelers properly equipped to actuate, by means of electric power, orange-peel and clam-shell buckets for use in excavating the trench, a compressed-air piledriver for driving the steel sheet piling, and a pipe-handling device which made rapid and easy the handling of the heavy sections of reinforced concrete pipe used. For the variety of machinery it describes the article is noteworthy.

The perfecting of the portable transformer has greatly stimulated the use of electrically-driven machinery in sewer construction and on similar work. This makes practicable the use of such machinery in undeveloped residential districts on the outskirts of cities where electrical power lines have not, as yet, been permanently installed. Similarly, electrical power is readily transmitted at high tension to the portable transformer at points remote from the source of power in the open country, where it becomes available for practically all the uses calling for power driven machinery on construction work.

In the field of sewage pumping the electrically driven pump has brought relief to many communities long subject to the back-flooding of storm sewers. For example, there has recently been placed in operation in the city of Boston the largest sewage pumping station in the world. The pumps in this station are driven by electric motors. The station was built to cope with the run-off from heavy rainstorms and its need has been realized and admitted since 1868. A steam-driven station would have cost over twice as much as the electrically-operated station and fires would have been kept banked all the time. Constant attendance would have been required at the steam plant. In fact it would have been necessary to keep a full crew on hand at all hours—three shifts a day—although all these men would have been idle nearly all the time, often for periods of several consecutive weeks. The attendance required by the electric station leads to but small annual expense.

In pumping house sewage the electrically-driven centrifugal pump already is a prime favorite with engineers and numerous installations are in successful operation. The advantages of these units are so well understood that they need not be enumerated. In view of these advantages the editor believes that such units should be installed in many localities to avoid deep excavations in sewer construction. The choice between pumping and deep trenches may well be predicated upon considerations of first and annual costs almost aside from other considerations. The reliability of operation, so long a bugaboo, need occasion little anxiety now since there is an excellent auxiliary source of power available in the gasoline engine in the rare event of electric current interruption. The dearth of sewage pumping stations in cities having long lengths of small sewers laid at great depth suggests the conclusion that engineers may well give more attention to comparing the cost of digging deep trenches with the cost of installing pumping stations, in one case the interest on the first cost being large and the other the annual cost of operation being very considerable.

In sewage treatment attempts have been made for many years to apply electricity directly to the crude sewage. Of late years a few plants have been installed which have produced satisfactory effluents. However, the best that can be said of this method of sewage treatment at present is that it is one of the best known methods of producing a satisfactory effluent at a prohibitive cost.

RESERVE OR STANDBY EQUIPMENT.

In estimating the cost of construction a common cause of error is failure to make adequate allowance for time lost during repairs. But perhaps an even greater economic mistake occurs in the conduct of the work itself through failure to provide reserve equipment. We refer now not to reserve or duplicate parts to be used in replacing those that wear out, but to reserve or standby machines in their entirety.

Gillette's "Handbook of Cost Data," p. 1467, states that "many large railways count on 8 per cent of the locomotives constantly in the shops"; and it is added that this percentage is about half the percentage of locomotives that were undergoing repair during the early 80's when locomotives had not reached their present state of mechanical perfection.

Large electric light and power companies usually provide one reserve boiler, engine and generator for every three in active service. This does not mean that 25 per cent of such equipment is constantly undergoing repair, but it does mean that the large power companies have found it economical to provide for continuity of operation by having a large percentage of reserve equipment.

Contractors of experience usually make similar provision for reserve or standby equipment, at least in respect of all the smaller plant units. Thus in the case of dump wagons, a well equipped contractor will have about two reserve wagons for every ten in active use. He figures that the interest and depreciation charges on the two extra wagons is more than compensated by the saving in time of teams and drivers that would otherwise be lost by an occasional breakdown.

Of course where a large, expensive plant unit, such as a steam shovel, is used, and where only one or two such units are needed, it is not customary to provide standby or reserve equipment. However, there are cases where it will be found economic to have an extra unit even though only one unit is to be kept in continuous operation. Take, for example, the construction of a concrete road. With a good mixer and a well organized gang it is not difficult to average 600 lin. ft. or more of concrete road 4 in. thick and 16 ft. wide per day. But troubles with the machinery are certain to occur after it has been long enough in use to have reached the point where wearing parts must be renewed. Hence delays for repairs are inevitable. These delays, coupled with others, usually reduce the average progress very materially, and in doing so the cost rises. If record is kept of the delays, it may be found that it would be economic to have an extra mixer always available on such a job.

The economy of having reserve equipment is a matter that has seldom received adequate consideration by contractors and engineers.

KEEPING RECORDS OF CHANGES DURING CONSTRUCTION.

Few structures are erected in which it is not found desirable to make changes from the constructions called for by the plans and specifications. Frequently construction is started before all the details are worked out, but more often does it happen that the designer or owner of a building insists on changes from the structure as originally planned, even after construction is well advanced. In such cases it is of greatest importance that all changes be recorded on the plans in order that the latter may represent the construction as actually built. It was not until it was found advisable to remodel a steel frame building that those in charge of it were brought to a realization of the importance of having a complete and accurate record of the existing construction. Repairs have often been started, based on the plans, only to find later that changes had been made during construction which were never recorded on the plans; and that it was necessary to hold up the work until a partial demolition indicated the exact character of the construction. Fortunately steel construction ordinarily is but partially or thinly concealed and it is therefore possible to ascertain the details of construction from an examination of the structure, without great difficulty.

In the case of reinforced concrete construction this is not true and designers and superintendents of construction should profit by the lessons taught in steel construction. Here it is of even greater importance that complete and accurate plans and specifications be kept on record. Since concrete is generally molded in place, and therefore affords greater opportunity for changes during construction, greater care will be necessary to assure the recording of changes. Unless explicit instructions are given to superintendents of construction, and unless the designing office co-operates closely with the field organization, it is extremely probable that changes will be insufficiently recorded, if at all.

In investigating an old concrete structure the plans afford the only means of determining the details of construction, except complete wrecking. If the plans do not accurately represent the existing construction it will be practically impossible to strengthen an existing structure so that it will safely carry additional loading. An inspection may disclose the quality of the concrete and its state of preservation, but it cannot disclose the percentage of the reinforcement or its position, nor will it always be possible to determine the exact size of members.

In foundation work it frequently happens that the exact size of the foundation units, and the depths to which they are extended, are not determined until the excavation is at least partially completed. In such cases it has been the exception rather than the rule to record exact details of the actual construction used, although the advisability for so doing can hardly be questioned. It is not sufficient that sketches be made in a notebook or on loose sheets of paper; the changes should be recorded on the original plans, as it is the latter which are consulted when changes are contemplated.

WATER WORKS

PROCEDURE IN MAINTENANCE AND OPERATION OF WATER WORKS AT SOUTH BEND, INDIANA.

The present estimated population of the city of South Bend is 65,000. The area is about 14½ square miles. It is essentially a manufacturing city. The water works system is, and always has been, municipally owned. The public water supply had its origin in an election held in 1872 at which the voters chose a gravity in preference to a direct pressure system. The first supply was drawn from the St. Joseph River and this source was utilized exclusively until 1880, when ten artesian wells were sunk. The number of artesian wells has been increased from time to time until now there are an even 100 of them. These wells furnish the entire water supply for the city at this time. The supply is not treated in any way. In the briefest terms, the water works consist of two pumping stations, known as the Central and the North Pumping Stations, 100 artesian wells averaging 110 ft. in depth, a 6,000,000-gal. reinforced concrete storage reservoir, a steel standpipe, and the distribution system of cast iron pipe. There are 8,000 flat rate and 4,500 metered consumers. The average daily consumption is 5,000,000 gals. The per capita consumption is about 80 gals.

Organization of the Water Department.

Executive Division.—The utility is in the immediate charge of the Superintendent of Water Works, Mr. John W. Toyne, who reports to the Board of Public Works. The organization of the water department comprises five divisions, namely, the executive, pumping, meter and inspection, distribution and stores divisions. The executive division occupies four rooms; the superintendent's office, the general office, the cashier's office and a fire-proof vault in which all records are kept. Adjacent to these rooms is the committee room used by the members of the Board of Public Works. There are four employes in this division: the superintendent of water works, the chief clerk and his assistant and the cashier. Collections are separated from the general clerical work. In these offices is transacted all of the business of the utility and all its records are kept on file for reference and inspection. In addition to the general accounting work of the clerical force, which includes the assessment and collection of water rents, both metered and flat rate, it is necessary to record and maintain the record of all equipment at both stations, of the entire distribution system inclusive of that for public fire protection, of all service connections either in use or installed for future use, of all meters owned or controlled by the utility, covering make, size, age, operation and repairs, the material carried for use by licensed plumbers' or the departments' use, and all miscellaneous data.

Pumping Division.—The pumping division comprises the two stations. The Central Station is operated by water power exclusively and there are only two employes there, the senior and junior engineers. They alternate on two twelve-hour shifts, taking the day shift week about. At the North Station there are also a senior and a junior engineer working week about on the day and night shifts. There is an assistant engineer on the day shift. There are two firemen, one on each shift, one helper and one general utility man, both on the day shift.

Meter and Inspection Division.—The meter and inspection division has its headquarters in a room at the North Station. This division in addition to making all service inspections maintains all the meters owned and controlled by the utility, and handles all shut-off and turn-on orders and answers emergency calls. This division is equipped with all the necessary appliances for testing and repairing meters and no meter is put into service that has not been proved on at least three different rates of flow to insure correct registration under all conditions of service. This division also maintains the 14 public drinking fountains and the 156 sewer flush tank services. The employes assigned to this division are a chief inspector, a repair man and six men who serve both as meter readers and inspectors. They also deliver water bills. It may be mentioned in passing that water bills are mailed only on request and only about 100 consumers have requested this form of delivery. Direct delivery of bills by water department employes costs much less than mailing.

Distribution Division.—The distribution division has its headquarters at the Central Station. It is in charge of the street foreman who has immediate charge of maintenance and such construction as comes up in connection with the distribution system proper. The service connections are laid by licensed plumbers as later described. This foreman has two men under him the year round—one spends all his time on hydrant flushing, inspection and repairs; the other spends all his time on main line work. Other help is taken on as needed.

Stores Division.—The stores division handles all the supplies and keeps a perpetual invoice of all materials in card form. It is in charge of the stock keeper who has his headquarters in the stock room at the Central Station. This division sets all taps for the plumbers doing work in connection with the distribution system and checks material used in connection with the services to the curb lines. Two automobiles are maintained by this division. Both are converted pleasure cars—one is a Ford, the other a 30-H.P. Studebaker. One auto is used in setting taps for service connections; the other is used wherever needed. The department does not own a horse. When horses were used it was a big day's work to set 7 taps; using the Ford 20 taps are sometimes set in a day. Mr. Toyne says that the cost of upkeep of the Ford is less than that for one horse.

There is a machine shop, for repair purposes, at the North Station. It is in charge of a machinist. The equipment comprises 2 engine lathes, 1 forge, 1 drill press, 1 grinding stand, and 1 planer. All repairs are made in this shop including the turning of the large pump plungers.

Pumping Station Equipment and Operation.

Central Pumping Station.—This station is operated by hydraulic power but an electric auxiliary is held in reserve. The power plant consists of three New American turbines of 200 HP. each, at rated head and speed, all geared to the main line shaft from which the pumping units are driven. The pumping equipment consists of two 2,500,000-gal. per day Platt Iron Works, duplex, double acting, outside center packed power pumps, and a 10x10-in. vacuum pump. These pumps were thoroughly overhauled recently. They were fitted with new valves and springs and were bedded to their foundations. New crank pins were set to replace those worn and loose. These pumps are operating very efficiently. The auxiliary electric equipment consists of a 300-HP. Fairbanks-Morse phase wound alternating current motor, complete with the necessary operating equipment. The motor is belted to the line shaft.

There is a concrete reservoir at this station which has been out of service for several years. There is also equipment at this plant for an air lift system, consisting of a battery of steam boilers and a Corliss engine driven air compressor. This air-lift power plant cannot be used economically and, therefore, is out of service. It is interesting to note that this equipment, though installed several years ago, has been operated but a few weeks all told. It forms a good illustration of the misapplication of good equipment, a phenomenon which recurs not infrequently in the water works field.

The total pumpage at this station in 1914 was 884,426,600 gals. The operating cost was 0.58 ct. per 1,000 gals. pumped. The average pressure pumped against was 77 lbs. Totals of 891 quarts of oil and 151 lbs. of grease were used. The South Bend Manufacturing Co. controls the water power and the water department holds $4,000 worth of stock in that corporation, thereby securing power at a very low cost.

Improvements contemplated at this station include the repair of the idle reservoir, the addition of a suction well to the reservoir, and a complete overhauling of the system of pipes to the 38 wells at this station so that the pumps can draw from a solid body of water at all times, the wells to flow by siphonic action to the suction well and reservoir.

North Pumping Station.—This station is new—it was placed in operation during 1914. This is an exclusively steam power station, and is thoroughly modern in every particular pertaining to the generation of steam and its application to pumping engines.

A view of the station is shown in Fig. 1. The building was designed by Freyermuth and Maurer with due regard to its location in a park. The exterior is finished with a dark brown facing brick, trimmed with cut stone. The roof is of red tile trimmed with a copper dome and flashing. The building is divided into four general departments: (1) The main pump room containing all of the new pumping equipment. (2) The north pump room containing the old equipment which is maintained in condition to meet emergency demands. (3) The boiler room containing all of the steam generating equipment, including that for coal and ash handling. (4) The repair shop for meter testing and general repairs.

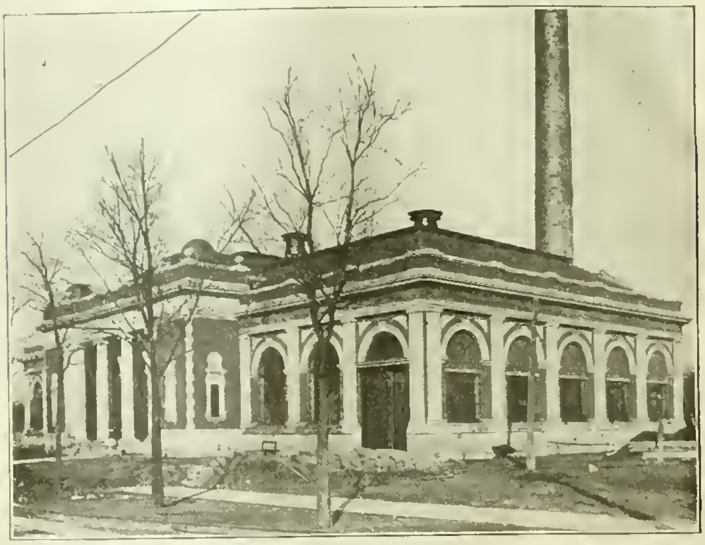


Fig. 1. General View of the New North Pumping Station of the South Bend Water Works.

The steam generating plant at this station consists of two batteries of boilers; one battery of two 150-HP. Babcock and Wilcox water tube boilers, and one battery of two 300-HP. Freeman water tube boilers. The boilers are kept in first class operating condition suitable for a 150-lb. working pressure by being put into service alternately. A boiler is not operated longer than 30 days without cleaning and inspection. The steam generating plant is complete with all modern auxiliaries and accessories. The coal is delivered, over the water works switch by the electric traction lines, in hopper bottom cars direct to the boiler room where it is dumped into pits, elevated by means of a Link Belt conveyor to the overhead bunkers from which it is fed by gravity to the stokers. These coal cars are set off of the Vandalia railroad at a point about three miles from the pumping station. They are hauled, by large interurban cars, through the heart of the city between 2 and 4 o'clock in the morning. The coal used is known locally as Indiana screenings and is purchased on a heat unit basis. The specifications were patterned after those in vogue in Chicago. The coal has a thermal value of 13, and contains about 10 per cent ash, 2½ per cent sulphur and 12 per cent moisture. The cinders are dumped to pits and are elevated to the dump cars by the coal and ash handling conveyor of the Link-Belt type.

The furnaces are all fed by Jones Underfed Stokers, the regulation being maintained through a Cole automatic regulator which proportions the rate of coal feed and draft to the steam pressure requirements. Each stoker is provided with a coal register and each furnace with a compound draft gage to assist the operators in securing economical combustion. The boiler feed is provided through a duplicate installation of outside end packed heavy pattern boiler feed pumps from three sources of supply (river, wells and mains), and with dual discharge from each pump to each boiler. The boiler feed water is pre-heated utilizing the energy of the exhaust steam from the auxiliaries and all boiler feed water is passed through a Lee V-notch flow recorder which automatically records the weight and rate of flow. There is also provided a flue gas temperature recorder and an automatic Hayes flue gas analyzer and recorder to determine the furnace efficiency. The gas recorder is checked at least once in every three months. The boilers are all equipped with balanced draft gages. The plant operates on forced draft and there is also a reinforced concrete and brick stack 78 ins. in diameter and 175 ft. high. All steam leads run to a main header from which there are individual leads to each pump.

The pumping equipment at this station consists of two 5,000,000-gals. per day (each) Allis-Chalmers horizontal cross compound crank and fly wheel high duty pumping engines with Corliss valve gear, one 6,000,000-gal. Dean horizontal tandem compound direct acting low duty pumping engine, and one 3,000,000-gal. engine of the same make and type. The high duty engines are equipped with hydraulic governors and, as an additional safety measure, with a fly ball type of steam speed limit. These engines operate at a duty in excess of 140,000,000 ft. lbs. per 1,000 lbs. of dry steam, and their operation is exceptionally smooth and quiet. The direct acting engines have a duty of about 60,000,000 ft. lbs. per 1,000 lbs. of dry steam. Thus the combined normal rated capacity of this station for high service is 19,000,000 gals. daily. All engines are carded at least once every 60 days.

In addition to this high service pumping equipment there is a duplicate installation of low service American Blower Co. engine driven Allis-Chalmers centrifugal pumps having a daily capacity of 8,000,000 gals. each, for use in maintaining the emergency storage in the 6,000,000-gal. reinforced concrete reservoir.

The engine rooms are provided with gage boards on which are mounted all of the necessary instruments for operation, including steam and water pressure gages, receiver and condenser gages, and suction gage. All are equipped with automatic recorders except the receiver and condenser gages. There is also mounted on the gage board liquid level recorders for making a permanent record of the water stage in both the suction well and storage reservoir. All of these recording gage charts are filed in the superintendent's office. In his office there is also a water pressure gage adjusted to show at all times the pressure at the North pumping station.

The pump suction is so arranged that any pump may be operated direct from the supply wells, from the suction well or from the storage reservoir. The water supply for this station is provided from a system of 62 artesian wells all normally discharging into the suction well from which full vacuum can be obtained by siphonic action. The suction well acts as an equalizer to the flow of the wells and provides a solid body of water for the pump suctions. The discharge from the high duty pumping engines is through a Venturi meter which acts as a check on the rated capacity and provides a permanent record of the rate of pumpage in chart form. The high duty pumps are capable of supplying the normal demand and the direct acting units are maintained for emergency use only. A test of the 62 wells at this station was made in 1914 and it showed that their combined output was 18,000,000 gals. per day. There is also, at this station, the emergency storage reservoir holding 6,000,000 gals.

South Bend has no fire engines. The pumpage is increased to meet the fire demand. This is usually from 100 to 125 lbs. although 150 lbs. can be given. The reservoir just mentioned holds a reserve supply for this purpose if needed. At least 1,000,000 gals. of water are pumped out of this reservoir daily to keep its contents fresh and suitable for domestic use. The bottom of the reservoir is at the same elevation as the main pump room floor and the top is just above the static elevation of the supply wells. This arrangement permits of direct flow to the pumps without vacuum and the replenishment direct from the supply wells at seasons of slight draught. During seasons of heavy draft, the reservoir supply is replenished by means of the low service pumps located in the station for that purpose. The reservoir as well as the suction well is equipped with a liquid level recorder by means of which a permanent record is made of the water stage at all times.

Both the reservoir and the suction wells were designed by Mr. William S. Moore, City Engineer. The design of the reservoir is appropriate to its surroundings; it is such that it adds to the beauty of the park while forming an essential feature of the utility.

The total pumpage at this station in 1914 was 927,916,329 gals., and the coal consumption was 3,778 tons. Totals of 2,858 quarts of oil and 61 lbs. of grease were used. The average pressure pumped against was 86½ lbs. and the cost of pumping was 1.8 cts. per 1,000 gals.

Improvements contemplated at this station are the installation of a track scale for weighing all coal delivered, and the construction of a storage track to form a track coal storage in emergencies as the bunker space is limited.

The Standpipe.

The steel standpipe is a portion of the first works installed in 1873. It is 5 ft. in diameter and 225 ft. high. The storage it furnishes is negligible but it makes a good open relief valve. The three connections to the standpipe are equipped with hydraulically operated gate valves. The control valves are located in the Central Pumping Station and are connected with an electrically actuated recorder for automatically making a permanent record in chart form of the position of the valves at all times. On an alarm of fire being turned in, the gates to the standpipe are closed and direct pressure up to 150 lbs. per square inch is furnished. Incidentally, fire alarms are turned in to the superintendent's office as well as to both pumping stations.

Extent and Maintenance of Distribution System.

The mains are all of cast iron, American Water Works Association Class C. specifications. The pipe is all laid with standard cast lead joints and with a 5-ft. cover. There are 121½ miles of mains ranging from 4 to 24 ins. in diameter.

The entire distribution system is flushed twice annually to improve the service and to prevent the accumulation of sediment in the mains. There are 13,731 service connections. Lead service pipes are used. All joints in services are wiped, and only licensed plumbers are allowed to work in connection with the water lines.

Public fire protection is provided through the fire hydrants. All hydrants are inspected at least twice annually and a record is kept of their physical condition, their static and dynamic pressure, and of repairs made to them. There is no trouble experienced from draining hydrants as the city is located on very sandy soil. In addition to these semi-annual inspections, frequent soundings are made during the cold weather to reduce the frost hazard to a minimum. There are 1,072 fire hydrants in service, of which number 859 are public hydrants. The other 213 are located on private property. Matthews hydrants are in the majority. Connections are 3 1/16 ins. outside diameter, 8 threads to the inch. While not standard this will take the standard hose coupling. There are 14 public drinking fountains.

There are 1,203 gate valves in the distribution system for controlling the flow. All valves are opened and closed at least once a year. These are being catalogued and valve records, like the hydrant records described, will be kept. The policy has been adopted of covering all valves under pavements with manholes, instead of the ordinary valve box, to render them accessible for inspection and repairs without cutting the pavement.

Meterage.

Of the 12,500 taps in service only 4,500 are metered, but the meterage system is regarded with favor and will eventually be universal. Meters are read monthly in business houses and industrial establishments where the bill exceeds $5 per month. Meters are read quarterly in low consumption business houses and in residences. The following set of instructions was prepared to govern the meter readers:

Give date when meter was read, also sign your name.

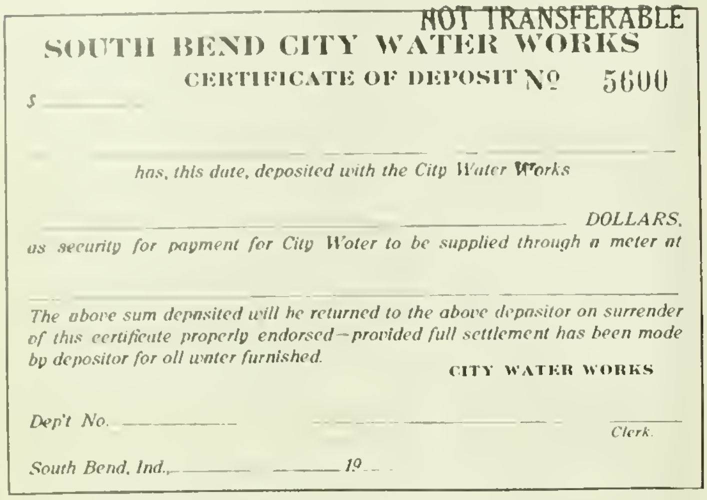
Endeavor to return reading of every meter for which you have a card.

Meter hole covers should be carefully replaced and tested to see that they are firmly seated.

Make record on side of "Remarks" by number, when possible. The figure "13" will mean that you had noticed the high consumption and that you were SURE THAT THE READING WAS CORRECT.

1. Meter not registering.
2. Closet in basement leaking.
3. Closet on first floor leaking.
4. Closet on second floor leaking.
5. Closet was leaking; been repaired.
6. Kitchen faucet leaking.
7. Bath tub faucet leaking.
8. Basin faucet leaking.
9. Meter coupling leaking, inlet.
10. Meter coupling leaking, outlet.
11. Meter registering slowly, indicating a leak.
12. Did not find any leaks.
13. Consumption high; reading is correct.
14. Consumption low; reading is correct.
15. Covered; could not read.
16. Could not get in house.
17. Premises vacant.
18. Glass broken.
19. Register broken.
20. Meter hole needs attention.
21. Water left leaking.
22. Sill cock or hydrant leaking.
23. Meter over-read.

Metering is optional with the consumer but he cannot return to the flat rate after the service is once metered.



NOT TRANSFERABLE

SOUTH BEND CITY WATER WORKS

CERTIFICATE OF DEPOSIT № 5600

$

has, this date, deposited with the City Water Works

DOLLARS,

as security for payment for City Water to be supplied through a meter at

The above sum deposited will be returned to the above depositor on surrender of this certificate properly endorsed—provided full settlement has been made by depositor for all water furnished.

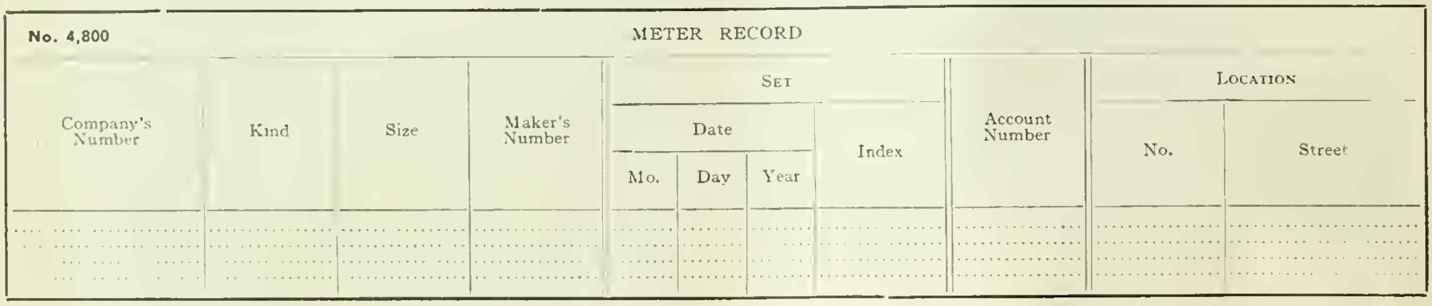
CITY WATER WORKS

Dep't No.

Clerk.

South Bend, Ind., 19

Fig. 2. Form of Certificate of Deposit, South Bend Water Works.

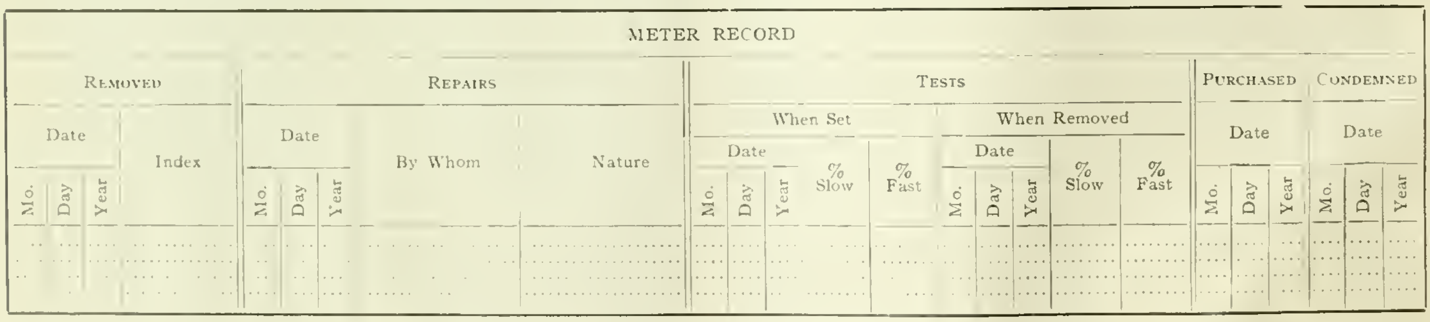


No. 4,800

METER RECORD

Company's Number	Kind	Size	Maker's Number	Set				Account Number	Location	
				Date			Index		No.	Street
				Mo.	Day	Year				

Fig. 3. Front of Meter Record Card, South Bend Water Works.

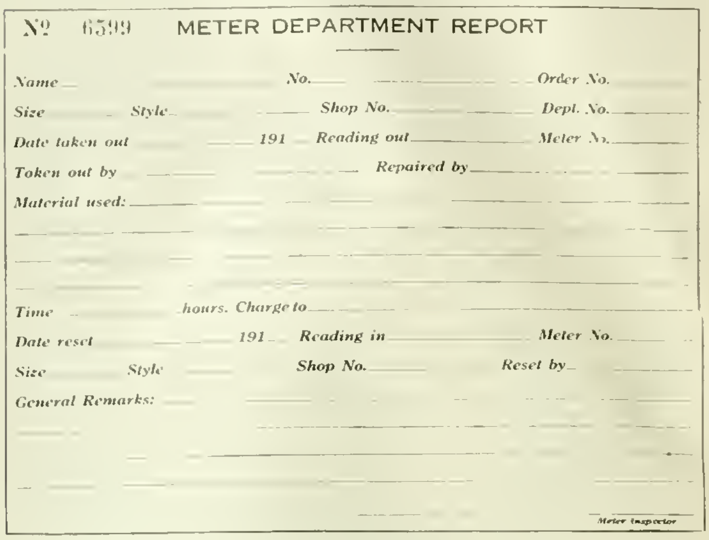


METER RECORD

Removed				Repairs					Tests										Purchased			Condemned		
Date			Index	Date			By Whom	Nature	When Set					When Removed					Date			Date		
									Date			% Slow	% Fast	Date			% Slow	% Fast						
Mo.	Day	Year		Mo.	Day	Year			Mo.	Day	Year			Mo.	Day	Year			Mo.	Day	Year	Mo.	Day	Year

Fig. 4. Back of Meter Record Card, South Bend Water Works.

A cash deposit of $5 is required of the consumer when his meter is installed and this money is retained by the department as long as the meter is in service. The form of the certificate of deposit is shown in Fig. 2. Interest is paid on this deposit at the rate of 4 per cent annually, computed semi-annually. The utility has instituted a system of meter records that will enable the superintendent to keep in close touch with the metered services and will prevent the continuous use of any meter for a period longer than two years without its being inspected and tested. The two sides of the meter record card are shown in Figs. 3 and 4. This plan insures good service to the consumer and a just return to the utility. Meters are tested by volumetric measurement by means of home-made apparatus. A calibrated measuring tank is used. In testing meters Mr. Toyne believes that the length of service should take precedence over the amount registered, so meters are tested after a certain period of use rather than after registering a certain quantity. The department retains ownership of domestic meters and pays for their maintenance. However, the consumer must pay for all repairs to meters made necessary by his carelessness, such as allowing hot water to back up into the meter or allowing it to freeze up and break. The form of report used in connection with meter repairs is shown in Fig. 5.



№ 6599 METER DEPARTMENT REPORT

Name No. Order No.

Size Style Shop No. Dept. No.

Date taken out 191 Reading out Meter No.

Taken out by Repaired by

Material used:

Time hours. Charge to

Date reset 191 Reading in Meter No.

Size Style Shop No. Reset by

General Remarks:

Meter Inspector

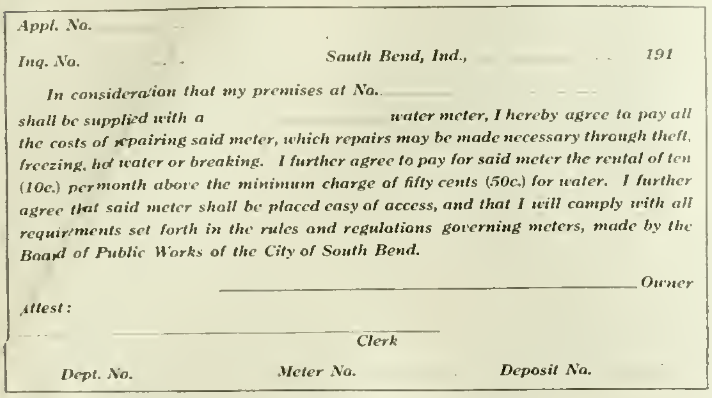
Fig. 5. Form of Meter Department Report on Repairs, South Bend Water Works.

Before securing a meter, the consumer must sign an agreement to pay the monthly meter rental and water bills. The form of agreement is shown in Fig. 6. The minimum charge for metered water is 50 cts. per month. All domestic meters are furnished and installed by the utility. Where the service is larger than 1 in., the consumer must furnish and install his own meter, which must be bought through or approved by the water department.

The department charges $1 for testing ⅝, ¾ or 1-in. meters. This is returned if the meter is more than 5 per cent fast. Other charges for meter testing are: 2-in., $2; 3-in. or 4-in., $5; 6-in. and larger, $10.

If a meter on test fails to register correctly, the bill for water used is based on an estimate from the last correct reading of the meter. Water bills are now collected with great firmness. Those who do not pay promptly are cut off. On Jan. 1, 1914, the delinquent accounts amounted to $5,558.82. Under Mr. Toyne's forceful handling of this matter that figure was reduced to $149.95 on Jan. 1, 1915.

Figure 7 shows the matter printed on the reverse side of the meter bills. This is intended to instruct the consumer and to popularize the meter with him.



Appl. No.

Inq. No. *South Bend, Ind.,* *191*

In consideration that my premises at No. *shall be supplied with a* *water meter, I hereby agree to pay all the costs of repairing said meter, which repairs may be made necessary through theft, freezing, hot water or breaking. I further agree to pay for said meter the rental of ten (10c.) per month above the minimum charge of fifty cents (50c.) for water. I further agree that said meter shall be placed easy of access, and that I will comply with all requirements set forth in the rules and regulations governing meters, made by the Board of Public Works of the City of South Bend.*

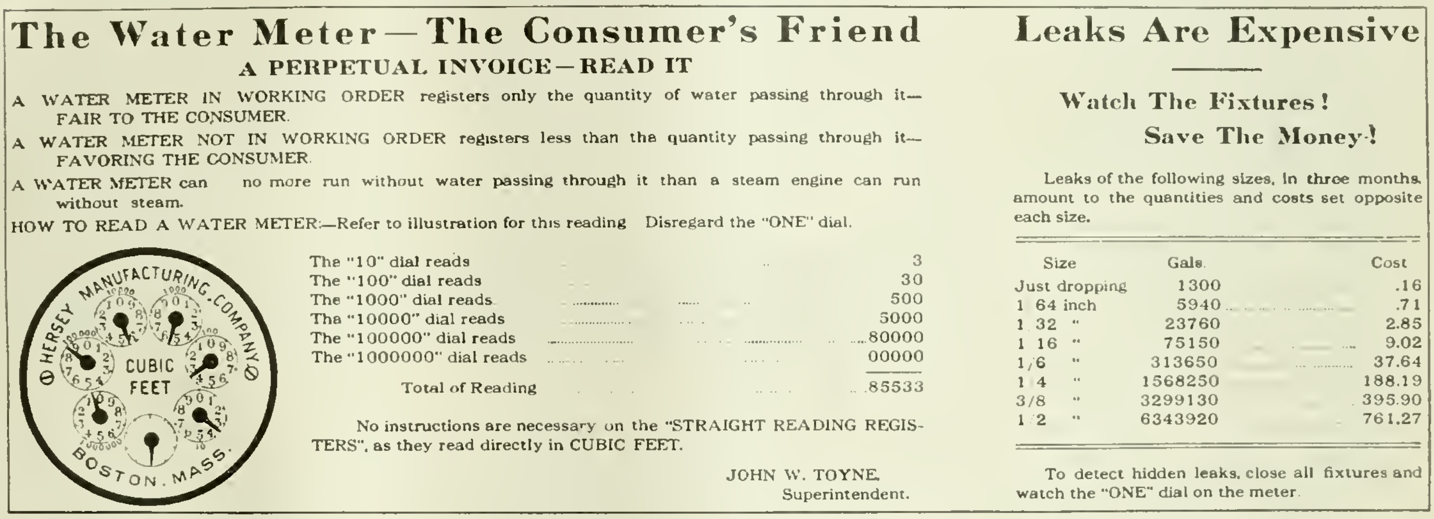
Owner

Attest:

Clerk

Dept. No. *Meter No.* *Deposit No.*

Fig. 6. Form of Agreement Signed by Applicant for Water Service, South Bend Water Works.



HERSEY MANUFACTURING COMPANY
CUBIC FEET
BOSTON, MASS.

The Water Meter—The Consumer's Friend

A PERPETUAL INVOICE—READ IT

A WATER METER IN WORKING ORDER registers only the quantity of water passing through it—FAIR TO THE CONSUMER.

A WATER METER NOT IN WORKING ORDER registers less than the quantity passing through it—FAVORING THE CONSUMER.

A WATER METER can no more run without water passing through it than a steam engine can run without steam.

HOW TO READ A WATER METER:—Refer to illustration for this reading Disregard the "ONE" dial.

The "10" dial reads	3
The "100" dial reads	30
The "1000" dial reads	500
Tha "10000" dial reads	5000
The "100000" dial reads	80000
The "1000000" dial reads	00000
Total of Reading	85533

No instructions are necessary on the "STRAIGHT READING REGISTERS", as they read directly in CUBIC FEET.

JOHN W. TOYNE,
Superintendent.

Leaks Are Expensive

Watch The Fixtures!

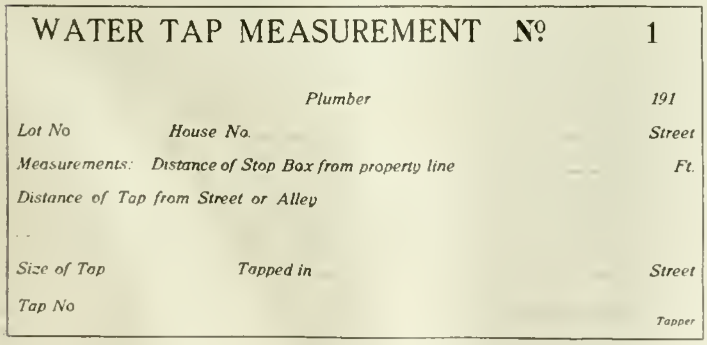
Save The Money!

Leaks of the following sizes, in three months, amount to the quantities and costs set opposite each size.

Size	Gals.	Cost
Just dropping	1300	.16
1/64 inch	5940	.71
1/32 "	23760	2.85
1/16 "	75150	9.02
1/6 "	313650	37.64
1/4 "	1568250	188.19
3/8 "	3299130	395.90
1/2 "	6343920	761.27

To detect hidden leaks, close all fixtures and watch the "ONE" dial on the meter.

Fig. 7. Educational Matter Printed on Back of South Bend Water Bills to Metered Consumers.



WATER TAP MEASUREMENT № 1

Plumber *191*

Lot No *House No.* *Street*

Measurements: Distance of Stop Box from property line *Ft.*

Distance of Tap from Street or Alley

Size of Tap *Tapped in* *Street*

Tap No

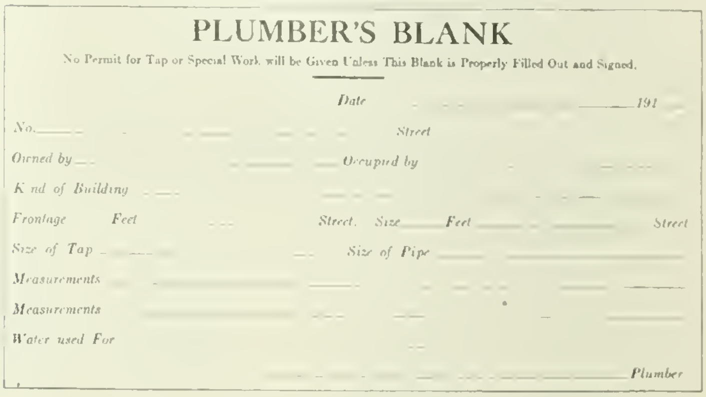
Tapper

Fig. 9. Form of Report of Water Tap Measurement, South Bend Water Works.

Service Pipes.

The person who desires water service needs only employ a licensed plumber who takes out a permit to do the requisite work. The plumber's blank is shown in Fig. 8. The plumber reports to the water department, on the completion of the work, showing the fixtures which have been attached. The work is inspected and the water turned on upon application. The plumber's report is approved and countersigned by the Inspector of Plumbing. Licensed plumbers only are permitted to work in connection with the water pipes or fixtures and they are not allowed to turn on water except to test their work. The same general procedure obtains when the consumer desires to install additional fixtures. Licensed plumbers are under $2,000 approved bonds. The license fee is $10 for the first year and $3 each year thereafter. Such licenses are issued by the Board of Public Works. Notice is left by the plumber at the water office the day before a tap is required and the tap is then made by the stores division of the water department.

Only ¾-in. services, as a minimum size, are now being laid to residences, although there are many old ⅝-in. services in use. "Extra Strong" lead pipe with all wiped joints is used. The utility furnishes to the plumber the service stop and stop box. The consumer pays for the installation of the service and must also maintain it. Only inverted key stop and waste cocks are permitted in the service stop box. The service pipe is laid sufficiently



PLUMBER'S BLANK

No Permit for Tap or Special Work will be Given Unless This Blank is Properly Filled Out and Signed.

Date *191*

No. *Street*

Owned by *Occupied by*

Kind of Building

Frontage *Feet* *Street.* *Size* *Feet* *Street*

Size of Tap *Size of Pipe*

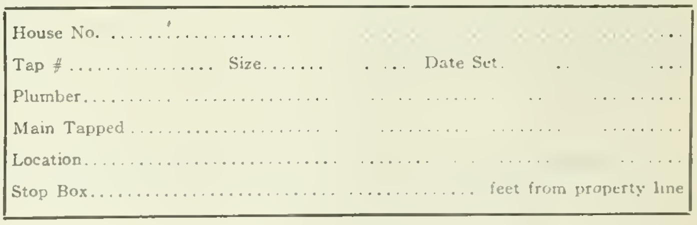
Measurements

Measurements

Water used For

Plumber

Fig. 8. Form of Plumber's Blank, South Bend Water Works.



House No. ....
Tap #................ Size....... .... Date Set.......
Plumber...
Main Tapped.......................................
Location...
Stop Box.. feet from property line

Fig. 10. Form of File Card for Keeping Tap Records, South Bend Water Works.

waving, with at least 1 ft. of extra length, to prevent rupture by the settling of the street. Services are given at least 5 ft. of cover. In refilling trenches in paved streets the backfilling is tamped in 4-in. layers to prevent after-settling.

The plumber makes accurate measurement and reports to the superintendent of water works the direction and distance from the nearest street corner to the stop box. He also reports the name of the street and the side on which the stop box is located. These reports are examined and approved by the Inspector of Plumbing and are delivered to the chief clerk of the water works; Fig. 9 shows the water tap measurement report blank, and Fig. 10 the form of the file card tap record.

On a ¾-in. service pipe, the following house fixtures are allowed: one each, wash basin, tank closet, bath tub, kitchen sink and a sprinkling connection. For additional fixtures the service pipe size is increased in the following proportion: 1-in. pipe equivalent to two ¾-in. pipes, 1¼-in. equivalent to three ¾-in.; 1½-in. equivalent to five ¾-in., and 2-in. equivalent to eight ¾-in. pipes.

The following table gives the minimum pipe sizes allowed for one fixture of the kind named:

Fixture.	connection, ins. Minimum pipe
Wash basin	⅜
Laundry tub	½
Bath tub	½
Sink	½
Urinal	½
Water closet	⅜
Sprinkling connection	¾

If the pipe supplying any fixture exceeds 16 ft. in length or contains more than two 90° bends the next larger pipe size is used than that called for in the foregoing tabulation.

Water Rates.

Water rates are always of interest to water works operators although it is now generally appreciated that they should not be copied without due allowance for local conditions affecting the cost of service. The list of annual ratings follows:

Bakery	$10.00
Barber shop, per chair	2.50
Bath tub, private	3.00
Each additional tub	2.00
Bath tub, public	$10 to 15.00
Beer pump	5.00
Blacksmith shop, first fire	3.00
Each additional fire	1.50
Boilers, per horsepower	1.00
Buggy wash, each	.50
Cemetery lot	.50
Church baptistry	2.00
Church organ motor	20.00
Closet tank, private	2.00
Closet tank, public	4.00
Closet hopper, private	3.00
Closet hopper, public	5.00
Closet, pan, private	4.00
Closet, pan, public	6.00
Dental spittoon	1.50
Dental motor	10.00
Domestic use	4.50
Gooseneck or high hydrant for domestic use	3.00
Hotel or large boarding house	12.00
Jeweler's motor	10.00
Slop sink	2.00
Pantry faucet	1.50
Office faucet	2.00
Photograph gallery, metered or rated	$12 to 20.00
Restaurant faucet	$10 to 12.00
Saloon or bar faucet	12.00
Sewing machine motor	5.00
Hammer motor	15.00
Sleeping room in hotel or lodging house	.50
Soda fountain	8.00
Soda fountain with spray or tumbler wash	12.00
Sprinkling, frontage 30 ft. or less	3.00
Sprinkling, each additional foot over 30 ft., per foot	.08
Sprinkling, side, per foot	.01
Sprinklers, mechanical (in addition to spkg.), per foot	.02
Stable, horse or cow	1.50
Sprinkling wagon, per month	15.00
Steam heater or furnace	3.00
Store faucet	5.00
Urinal, private	3.00
Urinal, public	5.00
Vegetable fountain	5.00
Wash basin, private	1.50
Wash basin, public	3.00
Washing machine motor	1.50
Circus, per day or fraction of day, including service of one man, per car	.30
Minimum	10.00
Circus, per day or fraction of day, private hydrant	6.00
Trenches, water for settling trench 4 ft. wide, 6 ft. deep, per lineal foot	.01
Sewer contractors, for back filling trenches, per lineal foot	.02
Sewer flushing from fire hydrant, per hour (no charge made less than $1)	1.00
Filling boilers from hydrants (including service of one man), per hour	1.00
Filling tanks, from 10,000 to 15,000 gals. (including service of one man)	2.00
Yard fountain, 12 hours per day for the season, 1/16-in. jet	10.00
Yard fountain, 24 hours per day for the season, 1/16-in. jet	15.00

Factories, laundries and livery stables metered.

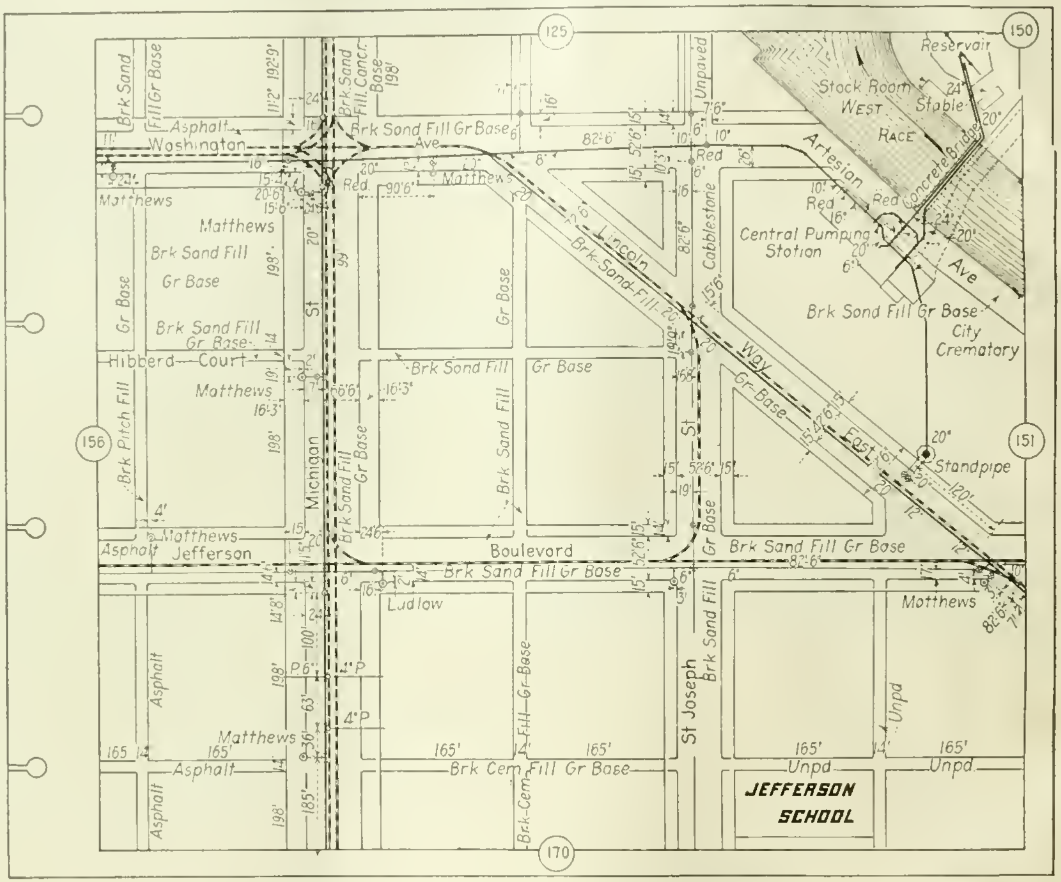


Fig. 11. Typical Sheet of Loose Leaf Record Book Showing Nature and Location of all Elements of Distribution System, South Bend Water Works.

METER RATES.

Meter rates per month: Minimum, 50 cts., meter rental; 10 cts.; first 80,000 gals., 12 cts. per 1,000; next 160,000 gals., 10 cts. per 1,000; balance, 8 cts. per 1,000.

Meter rates water for street paving purposes, per 1,000 gals	2.00

RATES FOR BUILDING PURPOSES.

For each 1,000 brick	.06
For each cord of stone	.15
For each 100 sq. yds. of plastering	.20
For each 100 sq. ft. of cement walk	.20
For each 100 running feet of cement curbing	.20
For each 100 sq. ft. of cement flooring, 3 ins. or less in thickness	.10
For each 100 sq. ft. of cement flooring over 3 ins. in thickness	.20
Sprinkling or dipping brick, per 1,000	.05
For each 100 sq. yds. of macadam pavement	.65
For each 1,000 cement block	.50
For each 100 cu. ft. of concrete	.30

In no case shall any permit be issued for water for building purposes for less than 50 cts.

Sprinkling.

The sprinkling privilege is allowed at any time during the day except between the hours of 4 p. m. and 8 p. m., during which time property numbering on the even side of the street must be sprinkled only during the even hours and the odd during the odd hours. This applies alike to flat and metered consumers. Sprinkling without nozzles or with nozzles larger than 3/16-in. opening is forbidden. This rule does not apply to metered consumers.

Maps of Distribution System.

Mr. Toyne has had made a complete set of maps of the distribution system. There are three large maps, hung on spring rollers, in a case on the wall of the superintendent's office. One of these maps shows all the distribution mains, valves, and hydrants in the entire city and the extent of street paving. The other two maps show in detail the layout of the supply, storage and pumping works at the North and Central pumping stations, respectively.

The distribution system is also thoroughly mapped on 16x19-in. sheets of tracing cloth. Each sheet is blueprinted and the prints are bound together in a loose-leaf book. A typical sheet is shown in Fig. 11. As will be noted, these maps show exact size and location of all mains, hydrants and valves, and also show the nature and extent of all street paving, street car lines, etc.

These sheets are numbered consecutively and are indexed according to street intersections arranged in alphabetical order. Thus in the index sheets each street appears in large letters in its proper alphabetical order and under this street name appears, again in alphabetical order, all the streets intersected. Opposite each of the latter is set the number of the map which shows the features of the distribution system at that street intersection.

Special attention is called to numbers in circles in the border line in Fig. 11. Thus if it is desired to look at the map showing the portion of the distribution system lying immediately north of the portion shown in Fig. 11, the ringed number 125 in the top border line indicates that reference should be made to sheet No. 125.

Preparatory to the preparation of these maps a complete field survey was made. The requisite data were all collected by the regular employes of the department, particularly by the meter readers and inspectors. These men rendered satisfactory service on this character of work. They were carefully instructed to start with and had no great difficulty in getting the information wanted, as time permitted from their usual duties. Only one extra man was put on during this work and he was of the same grade as the regular employes.

Some Miscellaneous Details of Operation.

Although reports on electrolysis have been made in past years the present superintendent has found no trace of electrolytic corrosion of mains. An Addressograph is a valued office adjunct and is used in making out the water bills. An aquaphone is of great service to the inspectors in locating leaks—they say they couldn't do business without it. Pitometer readings are made from time to time but no systematic water waste surveys have been made. Since the rate of consumption is only about 80 gals. per capita per day the need of elaborate waste surveys has not been indicated. Of course the inspectors are always on the lookout for leaks but this is incidental to their other duties. The department owns a wireless pipe locator and has had generally good success with it, although it sometimes locates buried horseshoes, etc., when water appurtenances are sought. There is also a large dipping needle which is exceedingly useful in locating buried valve and shut-off boxes. The force pump and paper wad method of cleaning services has been used to good advantage—it works well in 90 per cent of its trials. It works very good on short runs. About 50 ft. seems to be the limit of pipe which can be cleaned to advantage by this method.

The water mains are extended from three to five miles a year. This work is done by day labor. All joints are cast lead caulked by hand. A small amount of lead wool is kept on hand for caulking wet joints and for use in emergency repair work. New mains are tested under service pressure only. Generally new mains are laid a season ahead of the street paving. Mains are extended, ordinarily, out of the revenue of the department. If the sale of water will not pay 10 per cent return on the investment the cost of the work is apportioned against the abutting property until such time as that rate of return is realized. This rule is suspended when a new main is required from fire protection or public health considerations.

The accounting system used is that prescribed by the Public Service Commission of Indiana. This is a very elaborate scheme of accounts and requires the keeping of numerous charts. It is of forbidding appearance. It works well at South Bend, however, and is not found too extensive. In fact some supplementary accounts are kept for the superintendent's own information. The accounts are kept right up to date all the time without difficulty and with an exceptionally small but very efficient office force.

Superintendence.

During the year and a half of Mr. Toyne's tenure of the office of superintendent of water works many economies have been introduced. For example, the clerical work in the executive office is now handled by three persons where seven were formerly employed. Mr. Toyne believes that the secret of economic water works operation is to establish definitely the very best performance of which all elements of the plant are capable. Having learned this there is a mark for the employees to "shoot" at—the effort is then made to operate every unit as nearly as possible to its best efficiency as shown under test.

In the purchase of supplies the same methods are used in securing the best market prices as are used in the best regulated private industries. In buying cast iron pipe, for example, a definite quantity is contracted for to be delivered on demand at any time within a year, and an option is secured on as high as 300 per cent of the amount contracted for on the same basis of delivery within the contract period. In purchasing water meters it has been found advantageous to buy them in lots not exceeding a total expenditure of $500. At present only Hersey meters are being installed on domestic services. The superintendent's choice of this meter was based jointly on its performance and price. When Mr. Toyne took charge of the department he at once took up a study of the meter records on file. Curves were platted showing the maintenance cost of meters. Four standard makes showed practically the same maintenance cost under Sound Bend conditions, so the selection was based, finally, on the best obtainable purchase price.

Before becoming superintendent of water works at South Bend, Mr. Toyne had been actively engaged in engineering and contracting work for about 14 years. In view of the fact that the water system was operated for $8,000 less than in 1913, the mayor of the city in his 1914 annual message to the city council, said: "It has been shown that your Honorable Body made no mistake in raising the salary of the superintendent of the water works so as to permit the employment of an experienced water works engineer."

THE VALUATION OF WATER WORKS PROPERTIES.

IX. Prorating the Plant Value to Different Uses.

By Halbert P. Gillette.

Having ascertained the total cost or value of a water works system it is necessary to split up the total into at least two parts: (1) The part assignable to fire protection, and (2) the part assignable to domestic and commercial uses. Subdivisions of this second part are frequently made in establishing equitable rates of charge for the water used by different classes of customers.

Certain parts of the plant are directly assignable to the different uses. Thus, hydrants obviously relate to fire protection. Meters and services also are directly assignable to specific uses. Pumps, reservoirs and mains, however, must be prorated to the different classes of uses or customers. Upon what theory can the prorating be most equitably made?

The Separate Plant Theory of Prorating.

Study of the general problem of prorating plant costs and operating expenses for many sorts of plants has led me to what I will call the Separate Plant Theory of Prorating, which may be stated thus:

Where several classes of units of service or product are produced jointly, the total cost of joint production should be prorated among the several classes in proportion to the cost of producing each class (or its equivalent) by a separate plant and organization, designed solely for the economic production of the given number of units of that class.

At this time I will not attempt to discuss in detail the universality of this rule. A full understanding of it will, I think, make it clear that even the seeming exceptions to it are not exceptions, being in very truth "exceptions that prove the rule."

Joint production of different classes of service or products is an economic mistake unless the total resulting cost is less than the sum of the costs of producing the products separately or in joint groups of fewer classes. The saving effected by joint production is to be allocated to the different classes of products. The separate plant theory allocates this saving in proportion to the costs of separate production.

Suppose, for example, that one company was furnishing water to a city for fire protection only, and that another company supplied water for domestic and commercial purposes only. Suppose the owners of the two separate plants proposed to consolidate their systems and their operating forces, upon what terms could they come to an equitable agreement as to the division of the annual costs saved by the amalgamation? Clearly neither owner could fairly contend that the service rendered by his plant should be regarded as the indispensable service while that of the other plant should be regarded as a by-product. Since both services are economic necessities, it would become obvious to both owners that each would receive his fair share of the increased profits resulting from a joint service were such increase prorated in proportion to the profits prior to consolidation. Then if, prior to consolidation, each owner were making the same percentage of profit on his total annual cost of production (fixed charges plus operating expenses), it would follow that after consolidation each owner should receive his prorata of total profits in proportion to his total annual costs prior to consolidation. It is tacitly assumed, of course, that each of the two owners has an economic plant and operating staff.

Although the separate plant theory should be the basic theory for prorating joint costs, it is usually sufficiently close for practical purposes to adopt prorating rules that approximate thereto. Thus, the peak load theory of prorating is such an approximation. To illustrate: If a pumping plant is used jointly for two classes of service, it is usually practicable either to measure directly or to estimate the maximum horsepower developed by the pump when furnishing the "peak load" for each of the two classes of service separately. During a severe conflagration, for example, the pump might be called upon to operate at a 200 HP. load; but for domestic and commercial purposes 300 HP. might constitute its peak load. If the pump were designed to carry these two "peaks" simultaneously it would have a capacity of 500 HP. But ordinarily the peaks are assumed not to occur at the same time, so that the pump might be one having a capacity of, say, 400 HP. Or, if it were designed to be large enough to provide for future growth of the city it might have a capacity of 600 HP. In either case its cost would be prorated to the two uses in proportion to the two separate peaks, 200 HP. and 300 HP., respectively, or 40 per cent to fire-protection and 60 per cent to domestic and commercial use.

Similarly the mains may be prorated in proportion to peak or maximum demands for water in different parts of the city for the two uses.

When such proratings of joint plant items are made, it is usually found that the charges for hydrant rental have been much too low. Municipally owned water plants have generally, if not invariably, secured inadequate compensation for fire service. Usually the fire service has been erroneously regarded as a by-product and therefore chargeable only with the added cost of hydrants. Water companies have been drawn or forced into equally unremunerative rates for hydrant rental, either because the rates of municipally owned plants were used as a criterion or because the companies feared unjust reprisals if they demanded adequate rates.

Books of accountancy are often quoted in support of the proposition that "indirect (or joint) costs" should be allocated in proportion to "direct costs." While such a rule may serve sufficiently well in the case of merchants, for example, it is a rule that often leads to absurd results in cases where plant investment is considerable. In no instance is such a rule justifiable unless it gives results substantially in accord with the separate plant theory. Take the case of a water works system. Almost all of it is used jointly for fire and for domestic and commercial purposes. The only appreciable part of the plant directly assignable to fire protection is hydrants and their appurtenances. On the other hand services and meters, with their appurtenances, constitute almost the only part of the plant directly assignable to the domestic and commercial uses of water. Imagine, then the results that would follow the application of a rule that would come from prorating the rest of the plant—the jointly used plant—in proportion to the cost of hydrants on the one hand and services and meters on the other hand! When presented thus, the fallacy of such prorating becomes very evident.

Operating expenses are often segregated into direct expenses and indirect or general expenses, and it is the common custom to allocate the general expenses in proportion to the direct expenses. This, too, is a practice that should receive careful scrutiny in a rate case, for it frequently produces absurd results.

General expenses are sometimes allocated to different classes in proportion to the gross revenue derived from each class. And this also is open to serious question, unless it can be shown that it yields substantially the same result as is obtained by the separate plant theory.

Costs of accounting, which is a general or joint expense, is sometimes a function of operating expense or of revenue, but usually it varies more directly with the number of entries involved monthly. Hence it usually costs little or no more to handle the entire accounting for one large customer, like a city that buys fire protection, than it costs to handle the accounting for the smallest residence customer. On the other hand, a far greater part of a general manager's time and skill is usually involved in negotiating for and retaining the business of a large customer than of a small customer.

Many expenditures must be prorated between capital charges—additions to plant—and operating expenses. Here, too, the separate plant theory of prorating should be applied.

In the sale of water to certain customers it is necessary to regard the water taken by those customers as a by-product that would not be sold to them at all if a higher price were charged. Thus there may be a factory that has a well from which it can supply itself with water very cheaply. To sell water at all to such a factory it may be necessary for a water company to cut its price below the actual cost to the factory of pumping water from its own well. If the price thus secured is more than the resulting added cost to the water company, then it is economic and proper to take on such added business. When this is done, the rate charged is said to be a by-product rate or a rate based on "the additional cost theory." As a matter of fact this seeming exception to the separate plant theory is really an exemplification of it, for the separate plants—the company's system and the factory's well and pump—actually exist.

We may test the correctness of the separate plant theory at the other extreme. If perfectly general, the separate plant theory is inapplicable where the different products can not be produced separately, and therefore no theory at all applies. A simple illustration is found in a meat market. Chuck steak, sirloin and liver are on sale at different prices per pound; but it is impossible to determine their relative costs. They are joint products of beef, never producible separately. There is no way of logically apportioning the total cost of the beef to the jointly produced parts of the beef.

In certain classes of public utility service, telephonic services for example, there is sometimes a close approach to this condition of invariable joint production, and in those cases joint costs can probably not be allocated at all. But most kinds of public utility services do lend themselves to production by separate plants for the separate classes of service, and in all such cases the separate plant theory of allocating both fixed charges and operating expense will be found to be the key that will unlock many a perplexity.

Point of Application of Lime in Iron Removal Plant.—The process of iron removal from the ground water supplies of New Jersey is by means of lime treatment, aeration, or a combination of both, followed by sedimentation and filtration through pressure or gravity filters. In one plant in which lime is used, followed by aeration, sedimentation and filtration, the method of adding lime is worthy of consideration. The lime is added through a 2-in. pipe which extends a little over 30 ft. down into the well, so that the lime solution will be applied just below the suction. By this method the lime is thoroughly mixed with the well water before the water reaches the aerator.

Corrosive Action of Hypochlorite Fumes Harmful to Machinery.—In connection with sewage disinfection plants, it should be mentioned that much trouble is caused by housing pumps, motors, engines, ejectors, and other pumping or mixing machinery in the same building in which the hypochlorite is stored or the solution applied to the sewage. The fumes given off by the hypochlorite are very corrosive and rapidly disintegrate washers, bushings, shaftings, etc. There have been instances in New Jersey where considerable damage has been caused by the corrosive action of hypochlorite fumes on the pumping machinery. In all cases where machinery of any nature is required, the hypochlorite should be stored and applied to the sewage in a separate, well ventilated building.

BUILDINGS

CONSTRUCTION FEATURES OF THE SUBSTRUCTURE FOR THE OCEAN STEAMSHIP CO.'S TERMINAL AT SAVANNAH, GA.

(Staff Article.)

In our issue of Nov. 3, 1915, we described and illustrated the design of the Ocean Steamship Co.'s terminal at Savannah, Ga., and gave data on the methods and equipment used in erecting the steel superstructure. In this article we shall treat of the methods and plant used in building the substructure of this terminal.

The project, which is now nearing completion, includes a slip 225 ft. wide by 1,020 ft. long, having a depth of water of 26 ft.; a reinforced concrete bulkhead extending along the banks of the Savannah River and around three sides of the slip, a total distance of 2,590 ft.; steel freight sheds, surrounding three sides of the slip; an office building, at the head of the slip; and a system of tracks under the sheds having a total length of about two miles. The improvement covers about 20 acres, of which the freight sheds and office building occupy about 11½ acres.

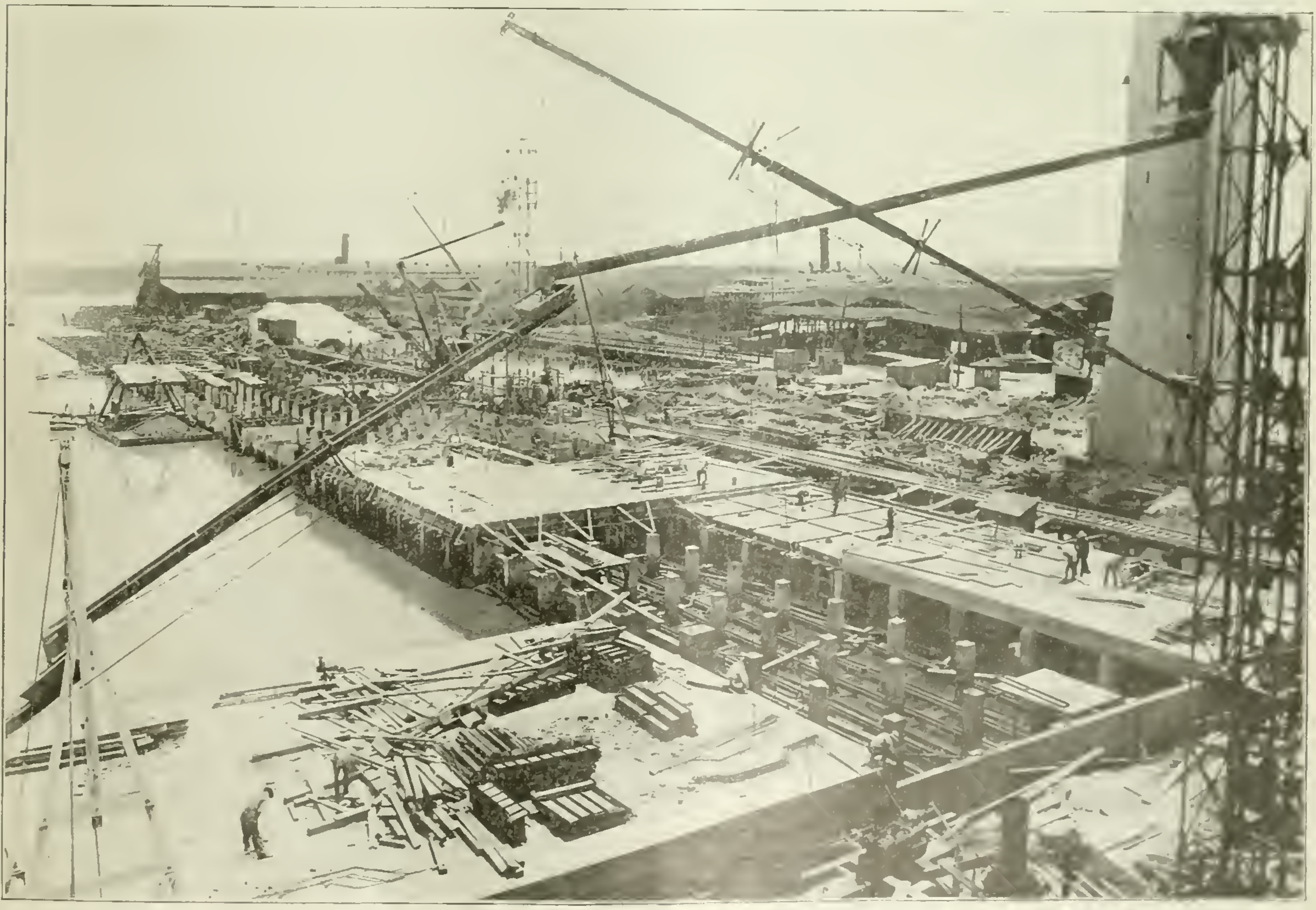


Fig. 1—General View Illustrating Methods and Equipment Used in Constructing the Substructure for the Ocean Steamship Company's Terminal at Savannah, Ga.

The substructure of the terminal is of reinforced concrete founded on wood piles. The concrete deck of the freight sheds is 12 ft. 9 in. above mean low water, and the timber fender extends 11 in. above the deck. Below the deck are the supporting concrete piers (in general spaced 10 ft. 10 in. on centers) and a system of concrete beams connecting the bases of the piers. Between the tracks there are reinforced concrete platforms, the latter being at the same elevation as the deck. In general, the deck slabs have a thickness of 9½ in., although this thickness is increased to 10½ in. at the end of the track pits.

Construction Features.

The foundation piles were driven with floating and land piledrivers equipped with Vulcan steam hammers. Considerable difficulty was experienced on this part of the work, as the bottom was very uneven and it was difficult to keep piles of the proper length on hand.

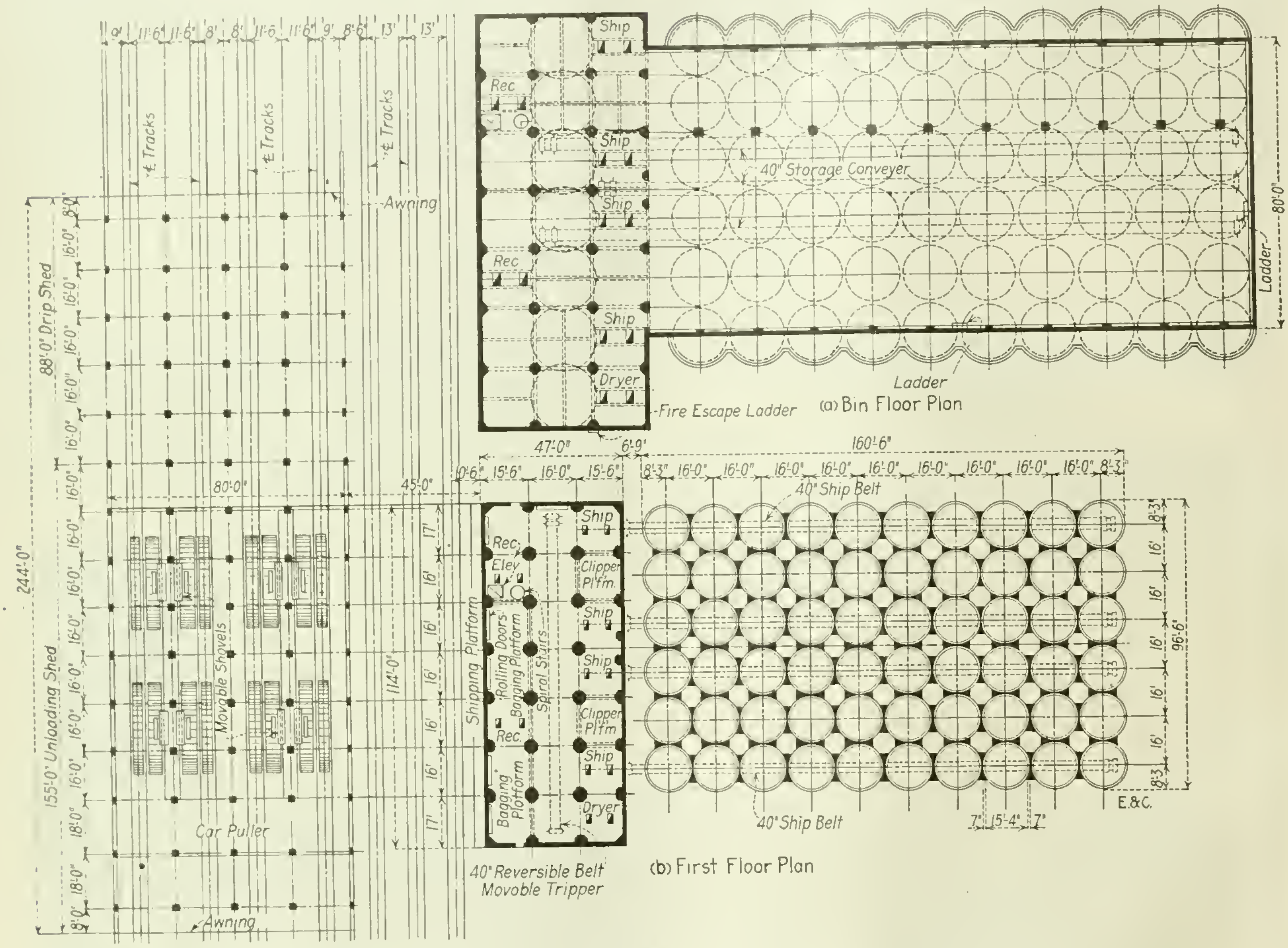


Fig. 1—First and Bin Floor Plans of 1,022,000-Bu. Public Elevator Plant at New Orleans, La.

The low-water beam concrete was placed in wooden forms, this part of the work being seriously hampered at the start by bad weather and high tides; after about March 1, however, the weather and tidal conditions improved and the work then progressed rapidly. The concrete in these beams was placed by means of buggies, as the small quantity in each beam precluded the use of chutes.

The greater part of the concrete in the substructure was chuted from the two steel towers shown in Fig. 1, the aggregates being handled from the storage piles by an Ohio locomotive crane into hopper cars which discharged into the side loaders of the mixers. Four Lakewood mixers were used on this work, two of 1½ cu. yd. capacity and two of ¾ cu. yd. capacity, the latter being equipped with side loaders. The ½-cu. yd. mixers were used at points beyond the reach of the towers; these were charged from wheelbarrows, the concrete being placed with buggies.

For the columns and bulkhead slabs Blaw steel forms were used with great success. The bulkhead slab forms were placed on flat cars and were moved from one location to another by means of tracks laid across the low-water beams (see Fig. 1). These forms were so designed that they could be lowered by jacks to clear the deck beams while being moved. For the track platforms, foundations and curtain walls timber forms were found to be more economical than steel forms.

Where a surface finish was required the surfacing was done with bush hammers operated by compressed air.

Personnel.

J. G. Basinger, of New York, is designing and supervising engineer for the terminal. The substructure and bulkhead were built by the Phoenix Construction Co., of New York, with J. A. Benham, superintendent in charge of construction.

DESIGN OF A MILLION-BUSHEL PUBLIC GRAIN ELEVATOR AT NEW ORLEANS, LA.

(Staff Article.)

To provide better export facilities for grain the state of Louisiana has authorized the Board of Commissioners of the Port of New Orleans to erect warehouses and other improvements necessary to develop the business of the port. This action was taken as the result of a thorough investigation of existing conditions by the New Orleans Board of Trade, the conclusions of the board being that a satisfactory solution of present difficulties could be obtained by the erection of a publicly owned grain elevator located on the tracks of the New Orleans Public Belt R. R., where it would be open to use on equal terms by all railroads entering the city. With the exception of one small elevator, all export elevators at this port are owned and operated by two railroads. Realizing the importance of the project the Board of Commissioners authorized its engineers to prepare a comprehensive report on the subject, and at the same time began negotiations for financing the construction of the elevator.

The board issued a full statement, setting forth the advantages in the plan of permanent financing which it, with the assistance of the local bankers, had formulated. As a result of this procedure the financing of the elevator was completed by the time the engineers had submitted their report showing the need and advantages of the contemplated improvement.

The board then instructed its engineers to prepare plans and specifications for the construction of an elevator with a storage capacity of at least 1,000,000 bu. It also requested the Board of Trade to appoint a committee to confer with the Board of Commissioners and its engineers in order that the design should meet all conditions relative to the grain trade of the port. After these preliminary plans had been approved instructions were issued for the preparations of detail plans and specifications. These plans provide for an elevator in which the rapid storage of grain from cars or vessels and its delivery to vessels, together with great flexibility in the distributing and conveying systems, are the essential features.

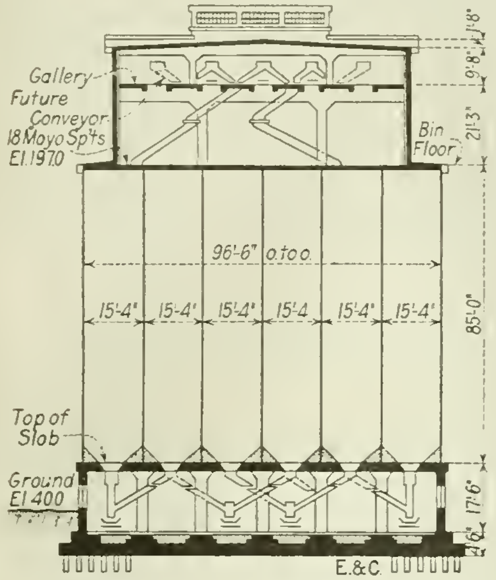


Fig. 3—Cross Section Through Storage Annex of Public Elevator Plant at New Orleans, La.

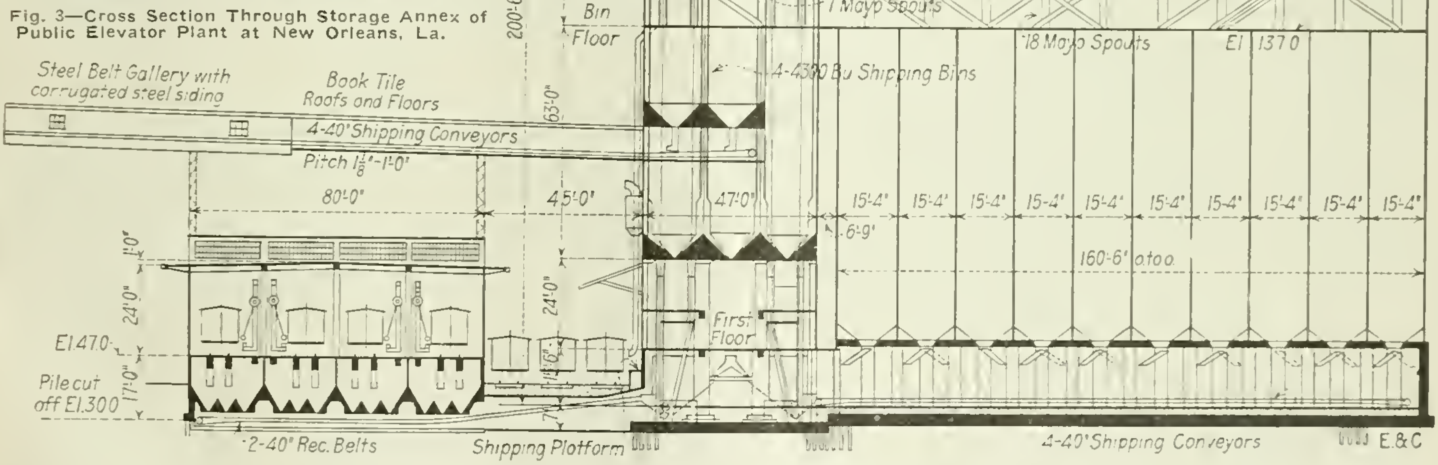


Fig. 2—Longitudinal Section Through Public Elevator Plant at New Orleans, La.

Site of Elevator and General Features.—The site of the elevator plant is on the river front at the head of Bellecastle St., about 1,000 ft. west of the new cotton warehouses and terminal. Practically all of the land located between Leake Ave. and the river and between Soniat St. and Peters Ave.—an area of approximately 70 acres—has been acquired for this purpose. In addition to the elevator plant proper the site will contain the tracks of the New Orleans Public Belt R. R., over which the grain will be delivered to the elevator. Particular care has been taken to secure an arrangement of tracks which will insure the rapid handling of cars. Through delivery tracks have been provided so that the cars, after passing the track shed, will be carried through into the main yards—stub ends are thus avoided.

The main plant will comprise a track shed, a drip shed, a working house, a storage annex, a drier house, a boiler house, a shipping conveyor gallery, a dock gallery, and a marine tower. All buildings, with the exception of the galleries, will be of reinforced concrete construction; the galleries will be of structural steel with book-tile roofs and floors. Figure 1 shows the first floor plan of the plant.

Track and Drip Sheds.—The track shed will be 80x155 ft., with a clear height of 23 ft. from top of rail to bottom of roof beams (see Fig. 1). The shed will house four unloading tracks, under which and at right angles to there will be the two conveyor belts which will carry the grain from the sinks to the receiving legs of the elevator (see Fig. 2). Each belt will be supplied by a battery of four independent receiving pits, provided with interlocking levers which control each battery and render it impossible to mix the contents of the different cars entering the receiving pits. The receiving belts, which will be located in water-tight steel chambers, will be 40 in. wide and will have a capacity of from 20,000 to 25,000 bu. of grain per hour.

The drip shed will adjoin the track shed on the west (see Fig. 1), its dimensions being 80x88 ft. Here the entering cars will be allowed to stand in order that water running from them will not drip into the receiving pits and thus come into contact with the grain.

On the east of the track there will be a four-drum car haul capable of handling a full train of loaded grain cars. The tracks in the shed will be on a grade running from the track shed, which will allow the cars, when unloaded, to move by gravity into the receiving yard for empties.

Working House.—From the receiving pits the grain will be delivered into the working house. This house will be located north of the track shed, and will be separated from the latter by a space of 45 ft. (see Fig. 1). It will be entirely of reinforced concrete, with a width of 47 ft., a length of 114 ft. and a height above the pile cut off of 208 ft. 6 in. The working house will contain 47 bins, ranging in capacity from 2,600 to 5,000 bu., with a combined capacity of 175,000 bu.

At the south side of the working house there will be two receiving legs equipped with 40-in. elevator belts, on which there will be two rows of 18x8x8-in. buckets. These receiving belts will take the grain from the transfer belts and elevate it to the top of the working house, where it will be discharged into the 3,000-bu. concrete garners.

At the north side of the working house there will be four shipping legs, of the same size as the receiving legs.

Each of these legs will have a capacity of from 20,000 to 25,000 bu. per hour.

In the basement there will be a 40-in. reversible transfer belt having a capacity of from 20,000 to 25,000 bu. per hour. This belt will receive grain from the working house storage bins and from the cleaning and clipping machines, and will deliver it to all the legs, both receiving and shipping.

The cleaning machines and the oat clippers will be located on the first floor of the working house. The arrangement of these machines is such as to allow the grain to be discharged direct from the bins into them and then spouted direct from the cleaning machines to the different elevator legs and the transverse conveyor.

In the cupola of the working house there will be two transverse conveyors, which will receive the grain from the hopper scale located directly below the garners. This feature, by which the grain can be delivered direct from the scale onto the transverse conveyors and from there to the storage conveyors or directly into the bins of the working house, is novel; it greatly increases the flexibility and rapidity of handling the grain through the working house.

The working house will be equipped with seven hoppers, each of 2,000 bu. spouted capacity.

The leg heads for all the elevators will be located on the top floor, while all the motors for driving the elevators will be installed on the floor below (see Fig. 2). The elevator legs, the conveyors, and the cleaning and clipping machines will be driven by separate electric motors, and will thus be independent of each other.

Storage Annex.—The storage annex, which will be located north of the working house (see Fig. 1), will comprise 60 circular tanks and 45 interstices. Each circular tank will have an inside diameter of 15 ft. 4 in., a height of 85 ft., and a capacity of 12,100 bu.; while each interstice will have a capacity of 2,690 bu. The total capacity of the annex is therefore 847,000 bu., which, with the 175,000-bu. capacity of the working house, will give a total storage capacity of 1,022,000 bu.

The design of the storage annex embodies several special features of interest. The basement, which has a headroom of 17 ft. 6 in., is entirely open, affording ample light and ventilation. The headroom permits the use of turn heads under the storage bins, which enable the grain from 48 bins to be delivered on one of the shipping conveyors, of which there are four, each with a capacity of from 20,000 to 25,000 bu. per hour.

In the cupola above the storage annex there will be three 40-in. storage belts and a system of "Mayo" spouts (see Figs. 2 and 3). Their design constitutes one of the new features of the elevator, and their flexibility is such that the center belt will be capable of delivering grain through the spouts to the 105 bins.

Shipping Conveyor.—As shown in Fig. 2, the shipping conveyor gallery will start at the south side of the working house, just below the four 4,300-bu. shipping bins, at an elevation of about 60 ft. above the ground level. It will extend out to the dock gallery, a distance of 400 ft., on a grade of 1⅛ in. to the foot.

In the shipping conveyor gallery there will be four 40-in. conveyors. These conveyors will discharge into hoppers in the marine tower on the dock gallery, which in turn will discharge onto the 40-in. conveyors in the dock gallery. This 1,300-ft. dock gallery will extend from the marine tower, in a direction parallel to the wharf, both to the east and to the west, a distance of 650 ft. The capacity of the shipping conveyors will be from 96,000 to 100,000 bu. per hour.

Along the dock gallery there is to be provided a system of spouts, spaced 60 ft. on centers, for both "first" and "second off" loading. The conveyors in this gallery will be so arranged that either one or both of them can be used for either purpose.

Marine Tower.—As has been noted, the marine tower will be located in the center of the dock gallery, at the point where the shipping gallery joins the dock gallery. This tower will be equipped with a leg having a capacity of 15,000 bu. per hour on the dip, and with a range in height sufficient to allow the leg to take grain from river barges or ocean vessels at any stage of the river. After being lifted from the vessel by the marine leg the grain will be discharged into the boot of the leg in the marine tower, which in turn will elevate the grain to a hopper. From this hopper one of the 40-in. shipping belts (two of which are arranged for reversible operation) will be used to convey the grain to the working house, where it will be weighed and sent to storage.

Drier House.—The drier house will be located on the east of the working house, and it will contain two driers, each with a capacity of 1,000 bu. per hour, when drying grain from 23 per cent moisture to 15 per cent moisture.

Provisions have been made for bagging grain in the marine tower and in the elevator. In the former the bagging platform will be located about 15 ft. above the wharf, where the grain will be weighed into bags by automatic scales and the bags sewed by automatic machines. Similar facilities will be provided on the first floor of the working house, where the bagging platforms are located.

In addition to the facilities described the elevator will be equipped with a complete signaling system, an intercommunicating telephone system, sanitary installations and a fire protection system.

Personnel.—The elevator was designed by Ford, Bacon & Davis, engineers, of New Orleans, La., under the direction of the Board of Commissioners of the Port of New Orleans. We are indebted to the engineers and to The Trade Index for the data upon which this article is based.

CONCRETE PLANT AND METHODS USED IN CONSTRUCTING HOTEL TRAYMORE, ATLANTIC CITY, N. J.

(Staff Article.)

The Hotel Traymore, completed during the latter part of 1915 at Atlantic City, N. J., is an 18-story structure with a total floor area of about 470,000 sq. ft. The work done in connection with this building consisted of making changes and additions to the 12-story tower of the old structure and the erection of a new fireproof building on the site of the old one. The site was cleared and construction of the new building was started Sept. 1, 1914, and the hotel was opened for business June 1, 1915. Nearly all of the reinforced concrete work was done during cold weather—between Dec. 24, 1914, and April 24, 1915. This included the mixing and placing of about 18,000 cu. yd. of concrete, the placing of about 1,500 tons of reinforcing steel and 1,200 tons of structural steel. As soon as the concrete work was completed and the forms removed the brickwork and partitions were placed; the cinder concrete floor and the concrete floor finish then followed.

Foundations.—The footings are of reinforced concrete, founded on wood piles. After the entire lot had been excavated to a level about 4 ft. below the sidewalk—about high water level—the piles were driven by means of a water jet, a follower being used in each case to sink them to the proper depth. The space to be occupied by each footing was then sheeted and the material excavated to the piles, after which the footing was poured.

Superstructure.—The superstructure consists of both reinforced concrete construction and structural steelwork fireproofed with concrete. In general the construction is reinforced concrete, with solid slabs, beams, girders, and concrete columns. Where large flat ceiling panels were required combination reinforced concrete joist and terra cotta tile construction was used. Where the column loads were very heavy structural steel cores were used to reduce their size, and steel girders were used where heavy load concentrations occurred due to the offsetting of columns.

Storage Yard.—The structure occupies the entire lot area and faces on one street only. This street is narrow and is blocked at one end by the board walk. As the site offered little space for the storage of materials a large storage yard was selected adjoining the railroad, where the cement was stored in a shed and where the reinforcing steel was stored and sorted. Bins were also constructed at this yard for storing sand and gravel, these materials being delivered to the site, as required, in motor trucks.

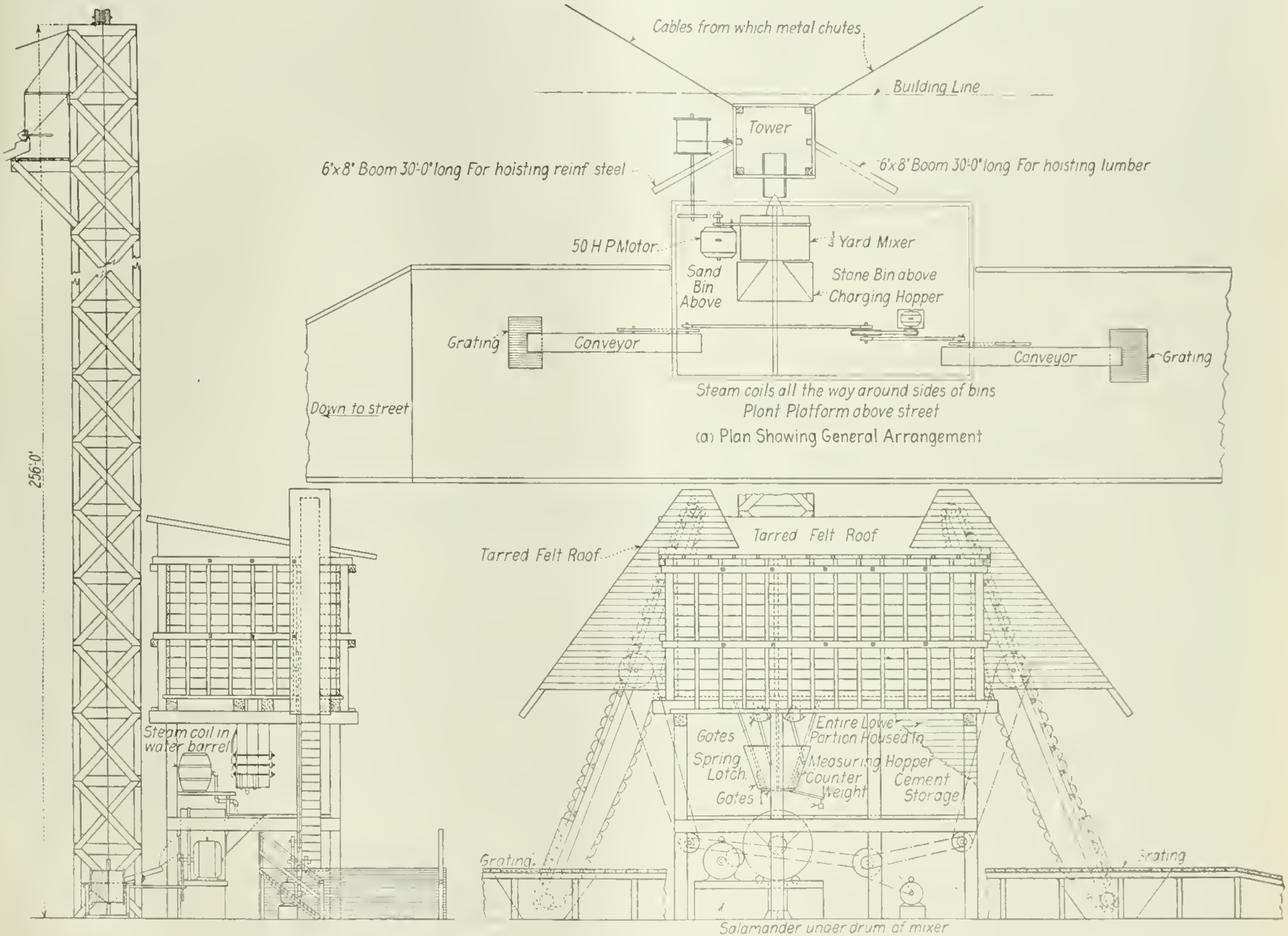

Cables from which metal chutes
Building Line
Tower
6'x8' Boom 30'-0" long For hoisting reinf steel
6'x8' Boom 30'-0" long For hoisting lumber
50 H P Motor
¾ Yard Mixer
Sand Bin Above
Stone Bin above
Charging Hopper
Grating
Conveyor
Conveyor
Grating
Down to street
Steam coils all the way around sides of bins
Plant Platform above street
(a) Plan Showing General Arrangement
256'0"
Tarred Felt Roof
Tarred Felt Roof
Steam coil in water barrel
Gates
Spring Latch
Gates
Entire Lower Portion Housed In
Measuring Hopper
Counter Weight
Cement Storage
Grating
Grating
Salamander under drum of mixer
(c) End Elevation
(b) Illinois Avenue Elevation
E&C

Fig. 1—Plan, Side Elevation and End Elevation of Concrete Plant Used in Constructing Hotel Traymore, Atlantic City, N. J.

Concrete Plant.—Figure 1 gives details of one of the two mixing plants used on this work. As shown in Fig. 1 (a) the sand and stone were delivered in motor trucks, which ran up inclined platforms and dumped the materials through iron gratings into separate hoppers, one for sand and the other for stone. The sand was raised to a storage bin by a Good Roads Machinery Co. bucket elevator and the stone to an adjacent bin by a similar elevator, as shown in Fig. 1 (b). From these storage bins the materials were discharged through gates into a graduated measuring hopper, which was divided into two compartments, one for sand and the other for stone. The entire bottom of this measuring hopper was made in the form of an iron gate, which was held shut by a spring latch. This latch was released by pulling a string, the weight of the materials forcing it open and allowing the sand and stone to drop into the 1-cu. yd. "Ransome" mixer. As soon as the measuring hopper was empty it was closed automatically by means of a counterweight.

As shown in Figs. 1 (b) and (c) the cement was stored in a bin and the water in a barrel, both being supported on a platform placed just above the mixer. The water was accurately gaged to insure the proper amount in each mix.

The two bucket elevators were driven from a single electric motor, as shown in Fig. 1 (a), while the mixer was operated by another motor. The latter, which was of 50-hp. capacity, also furnished power for operating the bucket in the hoisting tower.

The hoisting towers were 6x8 ft. in plan and 256 ft. high. After being hoisted the concrete was dumped into a distributing hopper, from which it was spouted to place in Insley chutes. Where the distance was too great to spout the concrete direct to place—on the upper floors—it was spouted as far as possible and dumped into a storage hopper, from which it was discharged into buggies and wheeled to place.

Facilities for Heating Materials and Protecting Concrete.—As much of the work was done during the winter it was necessary to take unusual precautions in mixing and protecting the concrete, the mixing plant being designed with particular reference to extreme weather conditions.

The sand and stone storage bins were lined with steam coils, and the bins were covered with a tar-and-gravel roof; this roof also enclosed the upper portion of the bucket elevator, as shown in Fig. 1 (b). A steam coil was also placed in the water barrel. In addition to these heating facilities a salamander was placed under the drum of the mixer to prevent cooling during the mixing of the concrete, and the entire lower portion of the plant was housed in.

To prevent the concrete from freezing after being placed in the structure each story was enclosed with canvas as poured, and salamanders were kept burning under each floor. In addition, as soon as the concrete floors were poured they were covered with a layer of salt hay. Although work was carried on continuously during the winter no trouble was experienced from frozen concrete.

Personnel.—The building was constructed by Cramp & Co., of Philadelphia. We are indebted to D. L. Kneedler of that company for the data upon which this article is based.

SEWERAGE AND SANITATION

A NOTABLE APPLICATION OF ELECTRICALLY DRIVEN MACHINERY IN SEWER CONSTRUCTION AT SALT LAKE CITY, UTAH.

Contributed by Bayard W. Mendenhall of the Utah Power & Light Co., Salt Lake City, Utah.

The Salt Lake Division of the Utah Power & Light Co. has been making rapid strides during the past two or three years in the introduction of electricity for contractors' use. The thing which has done most to make the use of electricity possible on many construction jobs was the introduction of the use of portable substations, one of which is here shown in Fig. 1.

One of the first jobs on which electric power was extensively used in the construction of sewers was the sewer extension No. 328 in Salt Lake City, which was awarded to the Ulen Contracting Co. of Chicago, and involved the digging of approximately 70 miles of trenches and the installation of sewer pipes varying in size from 6 ins. to 6 ft.

This contract involved the addition of practically as much sewer to Salt Lake City's system as had been previously installed during its entire history. It covered a territory of approximately five square miles, extending from West Temple to Sixteenth East St. and from Ninth South to Thirteenth South. Practically the entire district was heavily watered—the permanent water table varying from 2 to 10 ft. below the surface and in some cases it was a couple of inches above during certain seasons of the year. The removal of this water from the trenches quickly, safely, and economically, was one of the biggest problems in connection with the job, since, if this were not done, the excavation would be much more expensive. The power company found, upon studying the proposition, that its distribution lines paralleled approximately all of the trenches to be built, if not on the same street, within two blocks.

Electrically operated centrifugal pumps are well known to be most satisfactory for purposes of this kind where considerable quantities of water are to be handled if electric power is available for supplying them. The portable sub-station described above was first used on this job for that purpose.

Figure 2 shows the discharge of an 8-in. centrifugal pump operating in a manhole at Tenth South and State St.—on this cut a portion of the portable sub-station supplying it is shown near the left-hand margin. Two other pumps, one 4-in. and one 3-in., were necessary at this point to handle the large quantity of water encountered there; the trench is 16 ft. deep and water was struck at a depth of 4 ft. Twenty pumping outfits, aggregating 117½ HP., were used on this job.

On Tenth South, where a 60-in. pipe was installed at a depth ranging from 12 to 16 ft., an electrically operated excavator was used, a cut of the hoist equipment of which is shown in Fig. 3. An industrial track was laid spanning the trench along which this double drum hoist, operated by a 22-HP. motor traveled. A dead man supporting the cable was located approximately 600 ft. behind the hoist with a traveler operating on the industrial track between them at the point at which the excavating was being done. The hoist conveyed the buckets to the traveler, where they were lowered into the trench, filled, elevated, and carried back and dumped beyond the point where the pipe had been completed, thus filling the trench. This outfit proved to be far more satisfactory than a similar steam equipment which was tried, due principally to the fact that the high speed steam engine shook the platform excessively; the cost of operation was considerably less, together with all the advantages of electric versus steam power.

Electric power was also used extensively by W. M. Gibson in the work which he did on West 3d, 4th and 5th North Sts., Salt Lake City. Here the quantities of water to be handled were less than on the Ulen job. For that reason diaphragm pumps, both single and double mounting, were used, as they are better adapted for this purpose. Fig. 4 shows one of these equipments; a double diaphragm pump driven by a 3-HP., 3-phase motor mounted on skids for easy handling. No electrically operated diaphragm pumps were regularly made so far as could be determined and the outfit here shown was developed here in Salt Lake City by the Ames Agency in conjunction with our engineers. For this purpose, its operation was entirely satisfactory. The outfit handles readily 100 gals. per minute. It has the advantage that it does not require repriming in case the water in the sump is exhausted, as do centrifugal pumps. Four 3-in. double diaphragm and three 4-in. single diaphragm pumps equipped as above, as well as one 3-in. centrifugal pump, were used on this job.

The latest and most extensive application of electricity to this kind of work is to be found in the contract recently awarded to Gibbons Bros., Reed & Roche for the construction of an intercepting sewer extending from 9th North and 11th West to 10th South and 7th West, a distance of approximately 18,000 ft. or 3.4 miles.

A sectional concrete pipe will be installed, the inside diameter ranging from 60 ins. at its upper end to 78 ins. at its outlet. This sewer pipe will be laid in a trench varying in width from 8 ft. at its upper end to 11 ft. at its outlet, with an average depth of 20 ft. The digging of this trench will require the removal of 150,000 cu. yds. of earth. The northern end of the ditch passes through a district containing considerable underground water.

After studying carefully several different methods of handling the excavating of this trench and the laying of the pipe, Gibbons Bros., Reed & Roche decided on the exclusive electrical equipment herein described. The representatives of the sales department of this company worked in close co-operation with Gibbons Bros., Reed & Roche with that in view and were gratified to learn that the successful bidders decided that the equipment would be electrically operated.

The Utah Power & Light Co. had primary lines along the route of this sewer for most of its length. As the city will build a pumping plant at its terminus to lift sewage to the elevation of the gravity sewer outlet, the company built its transmission line along the sewer to its terminus for the remainder of the distance, which line is used to serve the excavating equipment. Two portable sub-stations, each equipped with three 50-KW. transformers are supplied, the one being used as a spare to be connected up ahead of the work, while the other is in service. Secondary cables consisting of three 400,000 circular mill cables are run out from the sub-station a distance of approximately 800 ft. either side. These cables are made up in lengths of 100 ft. and are connected together by means of junction boxes at which points the various pieces of apparatus are connected to the secondary feeder as they move along the ditch.

The ditch is excavated to a depth of approximately 5 ft. by means of horse-drawn scrapers. Beyond this depth it is not economical to use them. Sheet piling is then driven down, using a pile-driving traveler, which is seen in the foreground of Fig. 5. This crane is equipped with 2- W-1 and 2- S-1 Sprague electric hoists. The two forward ones are of one-half ton capacity and handle the interlocking sheet steel piling. The two rear ones are of one-ton capacity and handle the compressed air hammers which are used in driving the piling. These hoists are rope controlled from the ground. Compressed air for operating the hammers is furnished by an Ingersoll Rand compressor of 400 cu. ft. free air capacity belted to a 76-HP. General Electric motor. This compressor outfit is mounted on a truck and wheeled along an in-

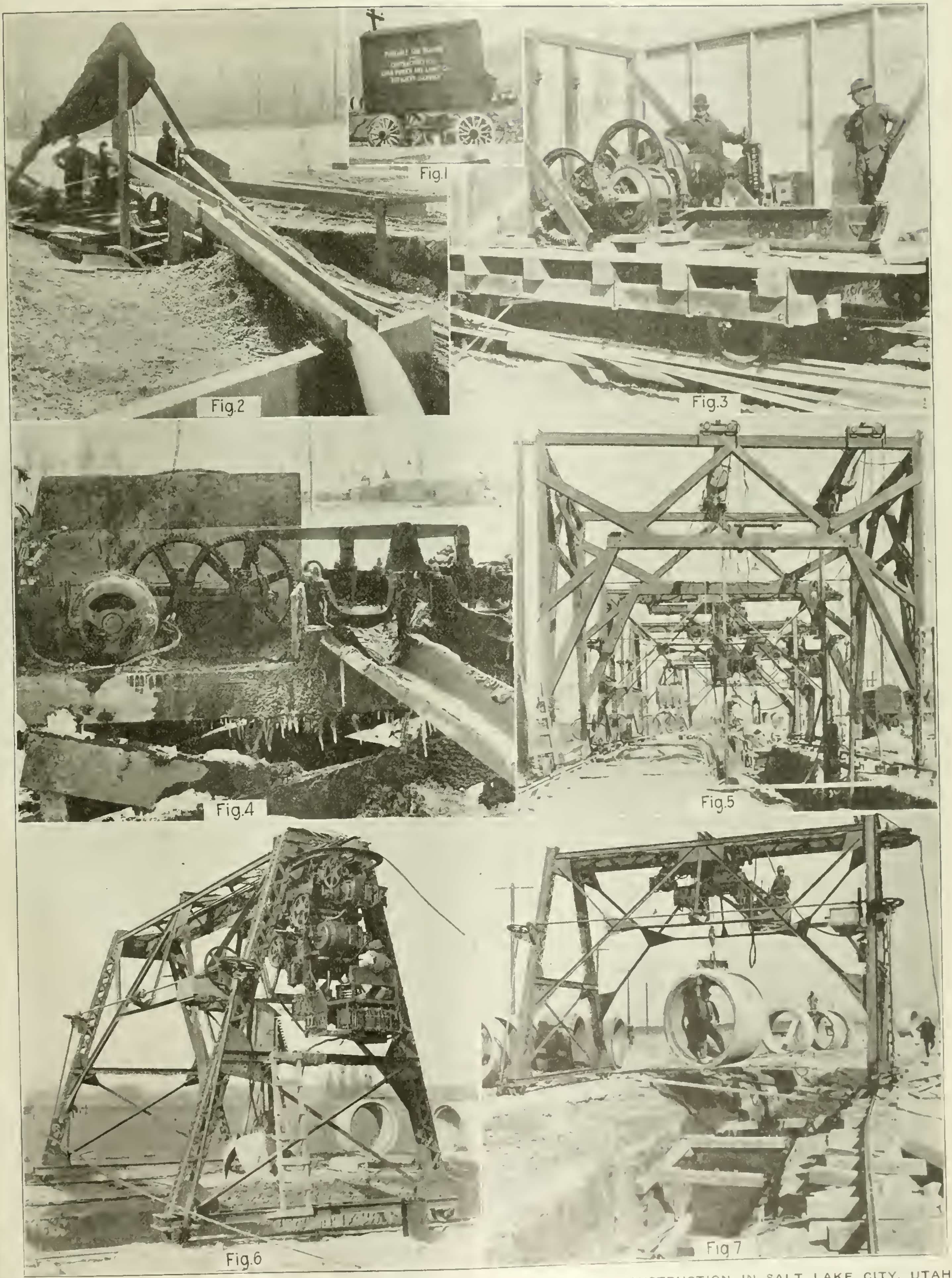


Fig.1

Fig.2

Fig.3

Fig.4

Fig.5

Fig.6

Fig 7

VIEWS SHOWING ELECTRICALLY OPERATED MACHINERY IN USE ON SEWER CONSTRUCTION IN SALT LAKE CITY, UTAH. Fig. 1—Portable Substation. Fig. 2—Discharge of 8-in. Motor-Driven Centrifugal Pump. Fig. 3—Hoist Equipment of an Electrically Operated Excavator. Fig. 4—Double Diaphragm Pump Operated by a 3-HP. Motor. Fig. 5—Electrically Operated Pile Driving Traveler. Fig. 6—Gantry Crane Equipped with Orange Peel Bucket for Sewer Excavation. Fig. 7—Electrically Operated Pipe Laying Crane.

dustrial railway beside the trench as needed. Two $\frac{3}{4}$-cu. yd. grab bucket gantry cranes follow behind the sheet piling crane and do the excavating. One of these cranes is equipped with an orange peel bucket, the other with a clam shell bucket. The former one is shown in Fig. 6. These electric shovels, as well as the pipe laying crane described later, were made by the Sprague Electric Works of the General Electric Co. Each of the digging cranes is equipped with four hoisting motors: A 10-HP. motor operates the holding cables. A 22-HP. hotor operates the drum which closes the bucket, called the lacing motor. A 6-HP. motor operates the cross travel of the carriage and a 10-HP. motor operates the longitudinal travel along the track. At the present time the dirt is being hauled away from the excavators in horse-drawn carts, but it is hoped to work out some more efficient way of handling this feature. After the excavation is completed the pipe laying crane picks up the lengths beside the trench and places them. This crane is shown in Fig. 7, equipped with a 30-HP. hoist motor, a 5-HP. trolley motor and a 10-HP. traction motor.

The electrical equipment includes four vertical shaft centrifugal pumps direct connected to 7½-HP. motors, which will be used in pumping water from the trench where needed. The aggregate connected load on this job is 256 HP.

It is a little too early to get reliable information as to the current consumption per cubic yard handled owing to the fact that the machinery is still stiff and the operators inexperienced, but all things considered, the equipment is proving to be all that the contractors expected of it. They are confident that they will be able to do the job more economically than they figured in their estimates on which their bid was based. The Power Company estimated a revenue of $5,000 from the job, and the preliminary indications are that this estimate will be not far from correct.

DESIGN AND CONSTRUCTION OF THE NEW SOUTH END SEWAGE PUMPING STATION, THE LARGEST IN THE WORLD, BOSTON, MASS.*

By Edgar S. Dorr, Office Engineer, Sewer Division, Department of Public Works, Boston, Mass.

Adequate sewerage facilities in the South End sewer district of Boston should have included a sewage pumping station as early as about 1865. However, such a pumping station was only recently constructed and has been in operation since July 1, 1915. During all these years there have been innumerable complaints and many investigations, but every investigation led to the same conclusion as that reached by the sewer committee of 1868, namely, that nothing really effective could be done except by pumping.

Station Made Possible by Developments in Electrical Pumping.

In old times this could mean nothing less than a steam pumping station, and one particularly difficult and expensive to maintain, on account of the intermittent character and irregularity in time of the service to be required of it. Inasmuch as a rain heavy enough to call it into action is liable to occur at any time, day or night, the station would have to be kept with banked fires and steam up at all times. This would require three shifts of men every 24 hours, and yet they would be idle the greater part of the time, sometimes for weeks together. The cost of installing an adequate station was estimated by the Sewer Committee of 1868 at $200,000. These conclusions seem to have effectively prevented any action.

The perfection of centrifugal pumps and electrical machinery and the establishment of reliable sources of electrical energy made a resort to steam unnecessary, and the station recently completed has been designed to be electrically driven and automatically controlled throughout. The starting and stopping of the pumps is governed by the height of the sewage, and very little attendance, comparatively, is required.

Equipment.

In the pumping station are installed three 36-in. submerged centrifugal pumps, each of 30,000 gal. per minute capacity, and one 26-in. pump with a capacity of 15,000 gal. per minute, against a static head of 13½ ft. The total pumping capacity of the station is 105,000 gal. per minute. Regarding one 36-in. pump as a reservoir unit, the normal capacity of the station is 75,000 gal. per minute.

The pumps are electrically driven. The motors for the 36-in. pump are 150 brake horsepower, constant speed, squirrel cage induction motors, having a synchronous speed of not more than 200 r.p.m. and a full load speed of about 194 r.p.m., when supplied 3-phase, 60-cycle alternating current at 440 volts at the motor terminals. The accompanying cut gives a view of the motor room of the sewage pumping station.

The 26-in. pump has a similar motor of 75 HP., having a synchronous speed of 240 r.p.m. and a full load speed of about 233 r.p.m. The total power required for the station, including the spare pump, is 525 HP. The pumping machinery is automatic throughout, each motor being controlled by a float which throws a switch at a certain fixed elevation of the sewage in the pump-well.

View of Electric-Motor Room of South End Sewage Pumping Station, Boston, Mass.

Construction.

The foundation for this station presented an interesting problem, the underlying material, shown by borings, for 37.5 ft. below street level (elevation 20) being a soft silt, except for a few feet of gravel, clay and ash filling on top. Then a stratum of 3.5 ft. of stiff blue clay was found, under which a soft clay or silt extended to hard bottom to a depth of 80 ft.

Two plans naturally suggested themselves; first, to drive comparatively short piles, stopping them in the stiff clay stratum; second, to drive long piles and trust to friction.

To test the practicability of the latter scheme it was determined to drive a test pile, allow it to rest a day or two and then load it until it yielded to determine the actual bearing strength. A pit was dug on the site of the proposed station and to the proposed grade of the foundation, and a test pile was driven 25 ft. below the bottom of the pit, the fall of the hammer and the resulting penetration being recorded for each blow. A long rod was driven into the head of the pile for convenience in observing settlement, and the pile was capped with a block of concrete. It was then loaded with pig-iron in 5-ton lots, with the following results:

Date.	Total load, tons.	Settlement, feet.
	0.21	
Aug. 4, 1913	5.43	0.005
Aug. 6, 1913	10.43	0.017
Aug. 8, 1913	15.43	0.020
Aug. 11, 1913	20.43	0.027
Aug. 13, 1913	25.43	0.032
Aug. 15, 1913	30.43	0.057
Aug. 18, 1913	35.43	0.159

At 25 tons loading, the yield began sensibly to increase.

---

*Extracts from paper before Boston Society of Civil Engineers as published in the December, 1915, Journal of the Society.

The pile formula—

$$\frac{(\text{Cubic root of fall in feet}) \times (\text{Weight of hammer in lbs.}) \times (0.023)}{\text{Last sinking in inches} + 1} = \text{safe load} \times 5$$

gave about 4 tons as a safe load.

It is a question whether any pile formula is applicable to a case like this, in which the pile does not bring up on anything resembling hard bottom. This pile, driven 25 ft. below the proposed grade of the foundation, of course pierced the clay stratum. It showed a little more resistance when going through it than when driven its full length. The problem was indeterminate, and its solution became a matter of judgment. It was the writer's preference to drive short piles, stopping them in the clay stratum, but this view did not prevail. Inasmuch as the pit for the substructure was to be sheathed with 6-in. grooved and splined Georgia pine, driven to the clay stratum, and therefore enclosing the soft material in a tight box, and as the foundation was to be a raft of reinforced concrete, 2½ to 3 ft. thick over the whole area of the box, it was finally determined to drive 25-ft. piles, which would result in a load of 8 tons apiece.

The pressure on the sheeting was severe. The excavation was braced to a row of piles driven along the center line and was well cross-braced, horizontally and vertically. The piles started to rise in the center, but this was checked by the prompt completion of the concrete foundation.

The concrete of the substructure was waterproofed with the Kennelly integral waterproofing, a liquid substance which is applied by mixing it with the water in the concrete. It is successful up to date, a few small leaks having developed, but having been stopped.

The superstructure is of brick, with a reinforced concrete roof, waterproofed in the same way, tarred and graveled.

The station was planned to have not only ample, but some surplus capacity, for several reasons. First, the limits of the ultimate extension of the pumping system are indeterminate. There is every gradation in the amount of suffering or inconvenience which has been experienced. The localities which, in the judgment of the Sewer Division, most needed relief have been selected, but there are undoubtedly many others which are now excluded which will demand and receive the benefit of the new system. This conclusion is rendered more probable from the fact that a singular difficulty was encountered in investigating the conditions in the South End. It was anticipated that many people would claim to have suffered more severely than they really had, and demand that the benefit of the new system be extended to their premises, when it was doubtful if it was really necessary. Just the reverse was found to be the case, owners denying having had trouble even where it was known that the premises were subject to flooding. The explanation is that the whole region being depreciated by the very condition for which a remedy was sought, the estates were unprofitable as investments, were probably heavily mortgaged, and the owners feared that their small remaining equities would be wiped out by a heavy sewer assessment. Such an assessment would be unjust, because the city is now only tardily making good a service which it should have rendered always. If this view prevails, then, as soon as it is known that the benefit does not entail an assessment, and the benefit to those estates which are connected are observed, demands will be made for considerable extensions of the system.

As previously related, the station was put in operation just before the phenomenal rain of the first of last July. This rain was certainly all that could be desired as a test, and the station handled it successfully and easily, only two pumps, the 26-in. and one 36-in., being called into action. But the tide, although in, was falling, and not particularly high, being at 9.40 at the beginning of the heavy downpour and at 6.50 at the end. The real test will come with a heavy downpour and unusually high tide.

The contract price for the machinery was $34,856. The building, including substructure, cost about $50,000.

SOME HINTS ON THE APPLICATION OF SEWAGE TO CONTACT BEDS.[*]

By Francis E. Daniels, Director of Water and Sewerage Inspection, New Jersey State Board of Health.

Following the practice employed at the sewage disposal plants at Essex Falls and Plainfield, N. J., considerable attention has been given to the method of applying sewage to contact beds through "scum restricting areas" or circular strainers. At these plants the tank effluent is applied on the top and at one corner of the contact beds. From a small area at the point of application, from 6 in. to 1 ft. of the contact material is removed from the top of the beds and the excavation is filled with fine cinders. An embankment about a foot high is constructed of the same material around this area so that all the tank effluent that is applied to the contact beds strains through the cinders. A great deal of suspended matter is thus removed from the tank effluent, and the clogging of the body of the bed is materially reduced with a corresponding increase in the effective life of the contact beds.

With the growing practice of reducing the storage capacity of sedimentation tanks, the value of underfed contact beds is diminishing. With a long period of tank storage, the tank effluent is usually very septic and contains considerable quantities of offensive gases. With a tank effluent of this nature, odors are probably reduced by having contact beds of the underfed type. With the present practice of constructing sedimentation tanks so that the storage period is reduced, the effluent as a rule is not septic, and offensive gases are not present to any great extent. In such a case the overfed contact bed is preferable to the underfed type.

In the overfed type of contact bed we believe that the use of distribution troughs or pipes to distribute the sewage over the surface of the beds is inadvisable. These troughs distribute the clogging suspended material over the whole surface of the beds, and sometimes require considerable cleaning and attention.

The cinder straining areas not only prevent, to a large degree, the clogging of the whole surface and body of the bed, but they serve as an index of the operation of the sedimentation tanks. The scum accumulating on these areas can be removed from time to time between doses. The rapidity with which the scum forms will serve to indicate to the attendant whether or not the tanks should be cleaned.

The results obtained at Essex Fells and Plainfield have been of such a nature that we have advised a similar application of sewage of the contact beds at other disposal plants, notably at Ridgewood, Collingswood and Roebling. The results have been entirely satisfactory, and similar changes will be recommended in the future at various other plants.

New Jersey Experience with Imhoff Tanks.—If properly designed, constructed and operated the Imhoff tank forms a valuable means of sewage clarification. The observation of the engineers of the New Jersey State Board of Health shows that under these conditions such tanks overcome a great deal of trouble due to odors and greatly simplify the sludge problem. However, their proper operation is a considerable problem, and the cost of keeping them in working order is several times greater than for septic or sedimentation tanks. An Imhoff tank should receive several hours' attention daily. The scum in the gas vents must be broken up and kept from forming a layer of considerable thickness, the sides of the sedimentation chambers and the slots may have to be scraped daily, and scum or floating material in the sedimentation chambers must be removed. In view of the initial cost of this form of tank as compared with the older single story types, the New Jersey engineers believe that in cases where the works are far removed from a populous community, so that the odor problem is not serious, it is doubtful whether the Imhoff tank has any material advantage over a properly constructed, well baffled sedimentation tank of the old type.

---

[*] From the 1914 annual report of the New Jersey State Board of Health.

ROADS AND STREETS

COMMENTS ON STREET CLEANING METHODS BASED ON PRACTICE IN CLEVELAND, OHIO.*

By Gus H. Hanna, Commissioner of Street Cleaning, Cleveland, Ohio.

The best street cleaning superintendent is the man you never hear about, because, if his work is done well, nobody ever thinks of him. If his work is neglected or badly done, he gets his name in letters an inch high on the front page of every paper. Yet, the street cleaning department is often the first agency of the city to feel the pruning knife, when it is necessary to cut down expenditures. That is how much glory there is in the street cleaning business. A street cleaner may save lives by combating unsanitary conditions, but he gets no hero medals and no monuments.

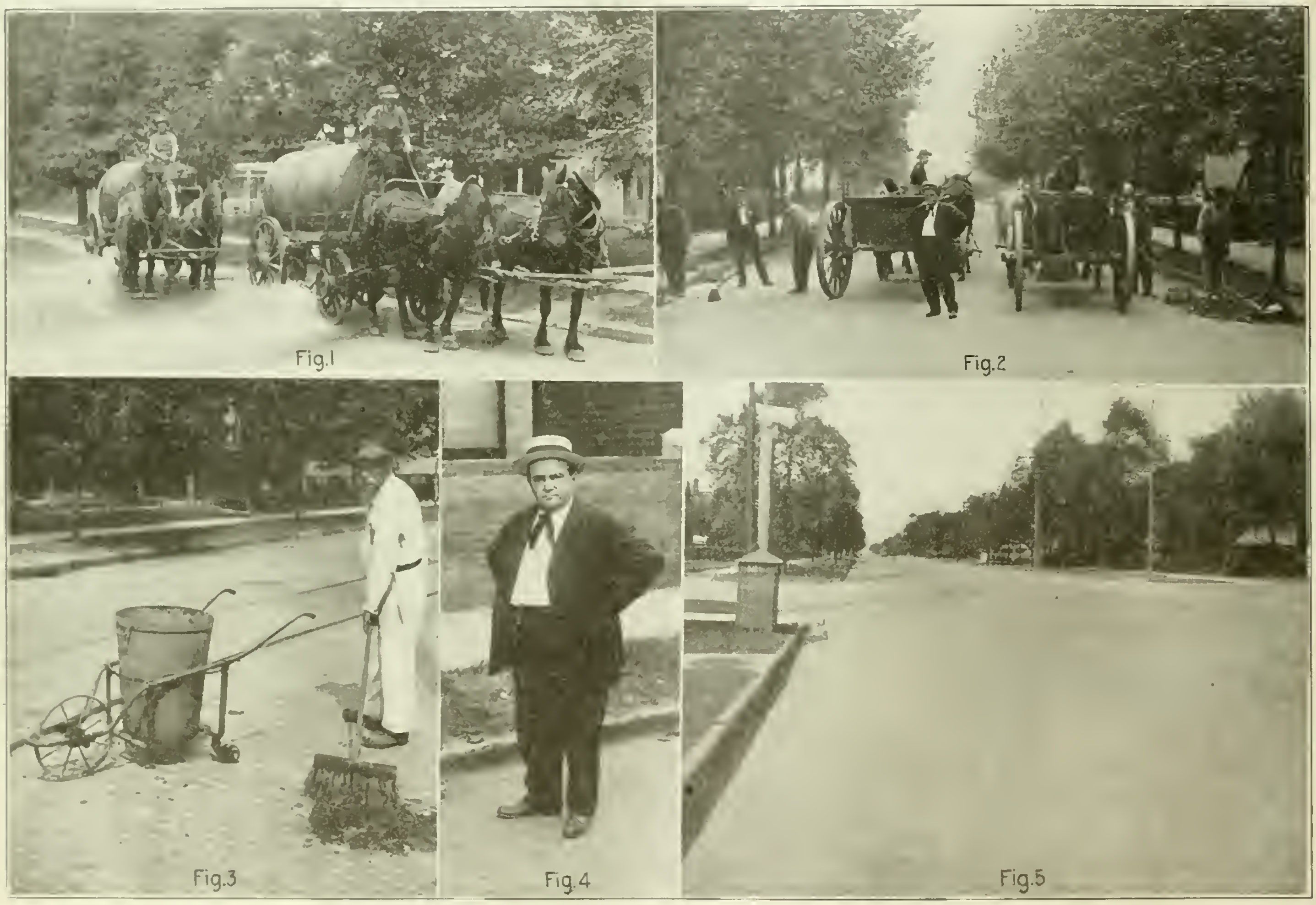


Fig.1
Fig.2
Fig.3
Fig.4
Fig.5

CLEANING BRICK PAVED STREETS IN CLEVELAND, OHIO.
Fig 1.—Automatic Flushers at Work. Fig. 2—Pick-up Squad at Work. Fig. 3—A Cleveland White Wing. Fig. 4—Commissioner Gus H. Hanna. Fig. 5—West Fourteenth Street, Cleveland.

I am not complaining of my job. I am simply explaining in advance why certain facts of which I will treat have escaped general attention. For example, it is common to divide paving costs under two heads, the cost of construction and the cost of repair. I maintain that the cost of cleaning is fully as significant a factor as the cost of repairs and is entitled to equal consideration in deciding any question of paving policy.

The street cleaner's task is more directly reducible to a question of dollars and cents than is the paving engineer's. When a street is clean, it is clean, and there are no degrees of super-excellence to aim for. It must be the superintendent's continual study to effect this cleaning as cheaply as possible, both because the public grudges money for street cleaning and because, if there is sufficient money, what is saved by economical cleaning can be applied to more frequent cleaning. Therefore economy must be the theme of any practical discussion of street cleaning. I will try briefly to tell you the result of my experience in three elements of economy: (1) The cheapest method of cleaning pavements; (2) methods of reducing litter, and (3) paving policy with a view to saving the cost of cleaning.

The use of flushers has proven not only the cheapest, but the most satisfactory method of street cleaning that our experience in Cleveland has been able to develop. We still make a considerable use of hand sweeping, but to make my point clear I need only refer to the statistics of our department, which show an average cost of 15.3 cts. per square of 10,000 square feet for flushing, to which must be added practically 9 cts. for pick-up work, a total of some 24 cts. per square as against 42 cts. for the work of the white wings.

The white wing is too convenient and necessary an adjunct to be wholly displaced under any conditions. Down-town streets must be swept continuously during the day and the hand sweeper, with his small cart, can also work to advantage in the gutters of residence streets, collecting dirt that has either been flushed or blown to the curbs. But so far as our experience goes, the lessening of cleaning cost by cheaper methods means simply the extension of the use of flushers at every practicable point.

There is an argument of sanitation in favor of the flushing method of cleaning. Dust breeds infection and is extremely unpleasant where it is not dangerous. Hand sweeping causes a certain amount of dust and mechanical sweeping usually causes still more. However, with all that can be said on this score, I am opposed to simple sprinkling as a means of laying dust. Ammonia and other products leach out of damp manure and form a scum on the surface of the street that is nearly impossible to remove and make the pavement slippery and foul smelling. Water should always be applied with force enough to carry the refuse to the gutter, where it should be promptly collected with brooms and shovels and removed.

---

*Extract from a paper before the International Road Congress, Worcester, Mass., Dec. 16, 1915.

The prevention of litter in streets has been carried farther, perhaps, in more congested cities than has yet been necessary in Cleveland. Even in our most crowded quarters, the street and sidewalks are rarely used as locations for garbage and ash cans, so one fruitful source of trouble in certain eastern cities is minimized in our case. We are reasonably successful in teaching the public to use waste paper boxes, but there is always room for improvement in such works of public education. We have tried during the past year to organize volunteer corps among school boys and girls who will use their influence against the useless littering of streets. The success of the venture is still at issue.

On the long run, nothing encourages carefulness on the part of the public so much as efficient and careful cleaning. A man does not hesitate to throw paper or rubbish into a street that is already foul. He thinks twice if the street is neat and clean. If there is a waste box at hand with a printed word of suggestion on the outside, he is apt to use the box.

The greatest source of expense in Cleveland has come not from those who use the streets for traffic, but those who use it as a place of business. A few hundred square feet near a certain street corner cost our department $10,000 to keep clean during the year last past. It is the location of a curb market, supposedly a farmer's market, but really the resort of professional hucksters who dispose of provisions that have often become shopworn in adjacent market houses before finding their way to the curb. It would be a small return for the privilege of doing business in the street to require these hucksters to keep their surroundings clean at their own expense, on pain of arrest or forfeitures of their privileges. My annual report recommends that some method be found of ridding the city of this form of imposition, and I think that if the principle is applied in most cities to their market districts it will result in a considerable saving of cost.

In certain localities the mud that is tracked upon pavements is the greatest source of cleaning cost. Paving policies should be carried out with a view to having a minimum number of unpaved approaches to existing pavements. I want also to point out the need of protecting narrow rural pavements from the overflow or tracking of mud that originates on adjacent portions of the same highway. Where half of a road is paved, care should be exercised to prevent the unpaved portion from draining across the paved portion. If the pavement is so narrow that teams must turn partly off from it at meeting points, the berms should be covered with broken stones or cinders to prevent tracking mud on the pavement. Few streets are so dangerous to auto traffic as a narrow suburban pavement with a film of fluid mud over it. The pitch frequently encountered on such pavements is enough when covered with slime to keep an auto continually skidding toward the curb. The cost of cleaning, under these circumstances, is higher than on other streets with ten times the traffic. With proper drainage, a shower ought to be a means of cleaning, not a means of contamination for an outlying pavement, even though it covers only a portion of the roadway.

But the foregoing measures are not so important or effectual in saving the cost of street administration as is the construction and maintenance of pavements that are easy to clean. It is a continual wonder to me that so little weight is given to cleaning cost when paving questions are settled. An annual expense of $500 a mile in repairing residence streets would be considered an appreciable item of maintenance, yet that figure for cleaning a mile of residence street through a season is extremely low. A cost of $500 for maintaining a mile of one kind of pavement for a year as against a cost of $1,500 for maintaining another kind would be sufficient grounds, in most cases, to decide in favor of the former material. Yet greater difference than this in cleaning cost as between competing types are blandly overlooked.

A street cleaner looks for two qualities in a pavement. It must be smooth and particles of litter must not stick to the surface. The question of smoothness opens up the whole matter of durability. Any material that deteriorates and roughens becomes more difficult each year to clean. Any neglect of needed repairs means a larger cleaning bill until the repairs have been completed. I do not think it is necessary for me to discuss the durability of materials. I merely wish to emphasize one thought that should enter into all calculations of expense, and that is the twofold expense resulting from wear, the cost of repairs plus the increased cost of cleaning.

Additional calculation of cleaning expense must be made for all bituminous pavements on account of the sticking of particles of litter to the surface. These surfaces are never quite so clean as non-adhesive materials and it costs from 25 per cent upward in additional cost to put them in a reasonably presentable condition, on account of this quality.

This difficulty is seen at its worst in a new creosoted wood block pavement, when the oil is gradually working out between the pores of the wood. The use of steel scrapers must often be employed, as the flushing by water is not effective at all in removing the dirt from such a surface.

The substances most easily cleaned that enter into pavements are brick and stone. Neither of them originates any form of dirt and both wash off readily. The only ground for discrimination between them is on the question of smoothness, where brick has a slight advantage as a rule. But in the use of these materials the choice of a filler is all important. A bituminous filler has all the disadvantages of a bituminous surface, from a cleaner's standpoint, and some others besides. Being softer than the brick or block, it recedes, leaving a crevice that invites the lodgment of dirt. With the edges of the brick or block unprotected it is sure to roughen, thus adding to the difficulties of cleaning. In fact, such a street, after a few years, presents an array of cobblestones, with the filler invisible, or else melted and run to the gutter, where it impedes the work of the follow-up gang.

So what I say in praise of brick and block pavements is meant to apply only to those built with a cement grout filler. I regret that I must rely upon general observations rather than exact data in supporting some of my statements, but it happens that we have in our office the result of observations made upon West Fourteenth St., in Cleveland, with view to determining the cost of cleaning. This is a grouted brick thoroughfare that has been paved some ten years and yet is in good enough condition to serve as a model of minimum cleaning cost. This street has a traffic of about two vehicles a minute. It has been cleaned, on an average, five times a week, being flushed by night and hand swept in the day time. The sweeper worked almost exclusively in the gutters, as most of the dust on such a pavement will be blown to the curbing in dry weather. The cost per cleaning amounts almost exactly to 15 ct. per 10,000 sq. ft., which we call a "square" and use as our unit of calculation.

This is the lowest figure that we have been able to achieve on any type of pavement. The cost on the best asphalt pavement would be not less than 20 ct. and would raise to 30 ct. as the surface became wavy or rough. A wood block pavement costs practically $1 a square to clean in its initial condition and it will be at least two years before the oil will have dried out sufficiently to admit of its being cleaned for 30 ct. a square. A tar filled block pavement will cost not less than 30 ct. per square, and, as the filler disappears and the blocks roughen, this cost will amount to 60 ct. or more.

So you can see how much weight I would put upon the question of cleaning cost in the selection of a material, as well as its construction. In the case of a pavement 40 ft. wide, there are about 21 squares to the mile. As between a material that can be cleaned for 15 ct. and one that can be cleaned for 30 ct., there is a difference of $3.15 per mile per cleaning, a difference of $15.75 per week, of $630 per season of 40 weeks and $6,300 in ten years. And instead of 30 ct. the cost of cleaning the latter pavement mounts to 60 ct. per square, as is not uncommon under conditions of wear, the excess of cleaning cost will be $1,800 for a year or $18,000 for a decade above the figures that we have shown to be attainable on W. Fourteenth St. The successes of our department and the good sanitary record of our city is attributable in no small measure to the fact that we have miles of this type of brick pavement.

Cleaning costs can be greatly reduced by a policy of prompt repairs. I believe in the continual patrol of all city streets by men whose duty it is to discover defects in pavements and prescribe repairs. Even from the standpoint of repair cost, such a system saves money. When cleaning is considered, as well as repairs, the saving of a patrol system is so great as to make any other system a luxury.

The bad pavement is the despair of the street cleaner. Every town has streets that ought to be called graveyards. There lie the remains of past paving failures, rutted, rough and unsightly to reproach the men who laid them. As a street cleaning superintendent my last word of advice is to tear such pavements up and build pavements in which you can take pride. Build for ease of traction, build for durability, but also build for sanitation. Build a pavement that can be washed and swept clean. Such a policy is not expensive. The real extravagance is to keep pavements on your streets that are a barrier to traffic, a breeding place for germs and a burden upon the street cleaning department to keep in a condition of halfway presentability.

In view of our experience and the economy of cleaning streets of one kind compared with that of another, as well as the difference in economy that is apparent to the man on the job, of a street out of repair and one in a maximum state for use, I wish to seriously submit for your consideration as to whether or not those who design, construct and select pavements have not lamentably failed in measuring the economy of a pavement by excluding every consideration that, which is involved in keeping them in clean, sanitary condition—confining their consideration simply to cost of construction, maintenance and repair?

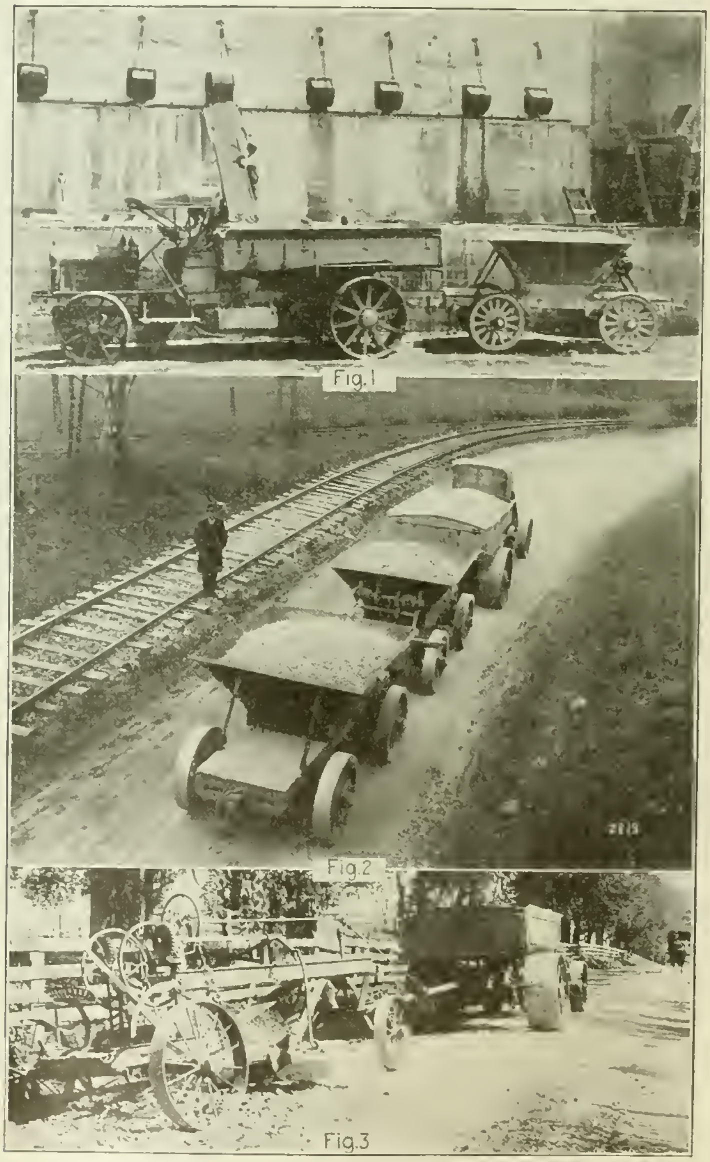
AN EXAMPLE OF MODERN PRACTICE IN ROAD IMPROVEMENT; FAYETTE COUNTY, KENTUCKY.

(Contributed.)

Fayette County, Kentucky, is establishing remarkable records in road improvement and setting a pace which few counties can hope to equal. Efficiency, aggressiveness and modern equipment have ended a half century of what seems to have been a state of lethargy compared to what has been accomplished in the present era of intensive highway development. The heart of Kentucky's far-famed blue grass country, the world's greatest loose-leaf tobacco market and a section rich in other products, notably thoroughbred horses, all of which Fayette County rightfully boasts, has 385 miles of road and all but five miles have been improved with waterbound macadam. Improved highways radiate from the city of Lexington to the county seat of all adjoining counties—Winchester, Nicholasville, Versailles, Georgetown, Richmond and Paris—while the larger distant cities, north, east and west, are connected by excellent trunk routes. The county embraces about 370 square miles, with one mile of improved road for every square mile of area; a population of about 56,000, with a mile of improved road for every 145 inhabitants.

The achievements of the present administration form an interesting highway romance. Frank A. Bullock, who as County Judge in 1896, wiped out the old toll roads by purchasing them for $352,000, today presides as Judge of the Fiscal Court with all the roads paid for and the county practically out of debt.

Two years ago, when the present County Engineer, Robert W. Davis, entered office, the county did not own as much road equipment as a wheelbarrow or a shovel. All county work was then done by contract. Engineer Davis, abolishing a custom almost traditional for 50 years, built up the facilities and the organization necessary for the county to do its own work, designed a centrally located supply station of 400 tons capacity, employing a gravity system in handling material from freight cars to roadways; built liquid asphalt reservoirs to store 24,000 gal., with steam heating equipment; erected a warehouse for storing machinery, cement, etc., and purchased the following road equipment: One White good roads truck for hauling road material and pulling road machinery; one White liquid asphalt distributor for surface-treating roads, two 4-yard Troy trailers; one elevating grader, one scarifier, two road rollers, two mixers and a rotary broom.



REPRESENTATIVE PLANT FOR IMPROVED ROAD WORK, FAYETTE COUNTY, KENTUCKY.

Fig. 1—Loading the White Good Roads Truck and Trailer at the New Gravity-Loading Plant. Fig. 2—White Good Roads Truck and Two Troy Trailers. Fig. 3—A Scarifier Being Pulled by the Good Roads Truck on an Old Macadam Pike.

With this equipment and with an organization of only 20 men, the county reduced the cost of hauling to the remarkable figure of 4.6 cts. per ton mile, rebuilt during the past season 22½ miles of worn-out macadam on seven different roads, laying about 1,200 tons of new metal per mile; built 30 concrete bridges; laid 8,000 ft. of culverts and distributed 80,000 gal. of liquid asphalt in service-treating about 25 miles of road.

In spite of the high speed work of Fayette County, Mr. Davis takes a far-sighted and conservative view of the road building question. In an address before the Kentucky Highway Engineers, he said: "If a community needs a good general system of roads today, the work should have been commenced 20 years ago. If a system is needed 20 years hence, it should be commenced now." And Fayette County is practicing what it preaches. Its facilities have been developed to take care of its needs for a long time to come and modern labor-saving methods have been employed at every opportunity. The handling of road material is a gravity proposition practically from quarry to roadbed.

Stone is obtained from 13 quarries, owned by the county but operated by contractors, supplying a central crusher manned by inmates of the county workhouse. This stone arrives at the county supply station in freight cars which are "spotted" on a siding and unloaded by gravity directly into the new concrete material bins. Each of the eight bins has a capacity of 50 tons and each has two outlets. When the White truck and trailers appear for a load, a traveling chute, reaching from bin to truck and running on a special track, is pushed along the front of the bins until it comes into position beneath the proper outlet. By pulling a chain which lifts the door of the outlet, the driver can load his truck in a few minutes. When the truck load is to be discharged the body is elevated by the patented power-dumping mechanism and the load is either deposited in a pile or spread to a uniform depth, whichever the foreman requires, thus completing the gravity system of handling from quarry-car to roadbed.

Even in the handling of liquid asphalt similarly scientific methods are employed. The same spur tracks that are built atop the material bins also pass above two 12,000-gal. tanks. When a carload of asphalt arrives it is "spotted" above the storage tanks, connected to the steam heating system and as soon as the asphalt is heated to a state of fluidity, it is also unloaded by gravity. These storage tanks also have interior steam coils to maitnain the asphalt in liquid form and facilitate its transfer to the tank of the White truck. The latter is equipped with its own steam heating plant, utilizing the well-known White steam generator and maintaining a temperature of 260 degrees, or higher if necessary. There is also a pump driven off the transmission of the truck, which forces the asphalt through the distributor and applies it to the surface uniformly and with great penetration.

By taking full advantage of the gravity system and keeping the truck and trailers busy, the county has built roads faster and at less cost. In 120 working days from May 1 to Oct. 31, 1915, the White truck and trailers hauled 5,882 tons, as shown by the following table of railroad weights of stone hauled through the county bins:

	Pounds.
May	1,742,300
June	1,368,100
July	1,801,300
August	1,970,700
September	2,690,440
October	2,191,720
Total	11,764,560

This tonnage was hauled at an average rate of 49 tons a day for 120 days, the distance being 4 miles one way. The cost of operation and maintenance was $9 per day; $0.184 per ton and $0.046 per ton mile. A saving of $43.77 was shown by a typical day's work of the truck and trailers hauling and spreading stone for water-bound macadam construction.

Hauling material is not the only road operation whose cost has been reduced. The truck is frequently used to pull a scarifier, Fig. 3. Occasionally it is used to draw an elevating grader as well as the common type of grader. Quite apart from its usefulness as a road-working machine, was the ability of the truck to haul 300 tons of coal to the county infirmary between periods of other work, saving a considerable sum of money in the price that was paid for the coal. Before purchasing the truck the only county work consisted of road patching operations in which case the rock would be dumped in piles along the side of the road and it was never in the exact place it was needed.

One of the important tasks for next season will be the construction of 23 miles of the Dixie Highway. About $400,000 is to be spent next season, first improving the main roads leading to the adjoining county seats and then the other roads leading out of Lexington. This work will consist of bituminous concrete roads built on top of the old macadam foundation. A large part of the work will be conducted under state aid but the county will reserve the right to do the work as a contractor and keep the cost as low as possible.

ESTIMATING GRAVEL ROAD MATERIAL QUANTITIES AND COST OF HAULING.[*]

Many localities in Iowa planning on graveling portions of their county and township road systems this winter or next spring are busy estimating how much material will be required and what the cost is likely to be. To make this matter of estimating both hauling cost and material quantities easier, the following tables will be of great help. The figures are derived from actual results recorded on many different projects and in different localities. Some items of cost, as of the price of sand and gravel available, freight charges, expense of labor and teams, will vary to a certain extent in different localities, but nevertheless the tables will be of great help in striking a general average close enough for an intelligent estimate.

TABLE I.—NUMBER OF LINEAR FEET OF 9-FT. ROAD A LOAD OF A GIVEN SIZE SHOULD COVER FOR VARIOUS LOOSE DEPTHS.

Weight of load			Length spread for loose depth in inches.			
Granite, lb.	Limestone, lb.	Size of load, cu. yd.	3-in.	4-in.	5-in.	6-in.
2,800	2,500	1	12 ft.	9 ft.	7.2 ft.	6 ft.
3,500	3,125	1¼	15 ft.	11.25 ft.	9 ft.	7.5 ft.
4,200	3,750	1½	18 ft.	13.5 ft.	10.8 ft.	9 ft.
4,900	4,375	1¾	21 ft.	15.75 ft.	12.6 ft.	10.5 ft.
5,600	5,000	2	24 ft.	18 ft.	14.4 ft.	12 ft.
6,300	5,625	2¼	27 ft.	20.25 ft.	16.2 ft.	13.5 ft.
7,000	6,250	2½	30 ft.	22.5 ft.	18 ft.	15 ft.
7,700	6,875	2¾	33 ft.	24.75 ft.	19.8 ft.	16.5 ft.
8,400	7,500	3	36 ft.	27 ft.	21.6 ft.	18 ft.

TABLE II.—NUMBER OF CUBIC YARDS OF MATERIAL PER MILE TO MAKE GIVEN LOOSE DEPTH FOR VARIOUS WIDTHS OF ROAD.

	Width of surfacing				
Depth of loose material in inches.	9-ft. Cu. yd.	14-ft. Cu. yd.	15-ft. Cu. yd.	16-ft. Cu. yd.	18-ft. Cu. yd.
1¼-in. (screenings)	180	280	300	325	367
3-in.	440	684	733	782	880
4-in.	587	913	979	1,043	1,174
5-in.	734	1,141	1,222	1,304	1,468
6-in.	880	1,369	1,466	1,565	1,760
Square yards of surface per mile	5,280	8,213	8,800	9,387	10,560

Knowing the cost of gravel in any community the cost of the material for the road can be easily determined. The cost of hauling the gravel varies also between rather wide limits but the following may be considered as average prices where teams cost forty cents per hour and where ordinary earth roads are hauled over:

TABLE III.—AVERAGE COST FOR HAULING GRAVEL BASED ON 40 CT. AN HOUR FOR TEAMS.

Length of average haul.	Cost, ct. per cu. yd.
One-quarter mile	21
One-half mile	28
One mile	40
Two miles	63
Three miles	86

SECOND ANNUAL SHORT COURSE IN HIGHWAY ENGINEERING AT THE UNIVERSITY OF MICHIGAN.

The University of Michigan announces its second annual short course in Highway Engineering to be given in Ann Arbor, Michigan, Feb. 21 to 25 inclusive, 1916.

Instruction will be given in road building by members of the faculty of the College of Engineering in co-operation with the Michigan State Highway Department. Additional instruction will be provided for by special lectures given by men noted in their particular line of work. These lectures are listed as follows: "The Economic Design of Highways with Reference to Traffic," by Arthur H. Blanchard, Professor of Highway Engineering, Columbia University; "Bituminous Surface Treatment for Water-bound Macadam and Gravel Roads," by Chas. F. Reeve, Chief Chemist of the Office of Public Roads, Washington, D. C.; "The Maintenance of Earth Roads," by W. S. Gearhart, State Highway Engineer of Kansas; "Specifications and Contracts," by H. K. Vedder, Professor of Civil Engineering, Michigan Agricultural College; "The Duty of the County Road Commissioners," by Wm. Kelly, Chairman of the Dickinson County Road Commission; "The Highway Engineer as a Public Servant," by Ira O. Baker, Professor of Civil Engineering, University of Illinois; "Road Maintenance," by Frank F. Rogers, Michigan State Highway Commissioner.

---

[*] Extract from Iowa State Highway Commission Service Bulletin, December, 1915.

This short course will be open to engineers, highway commissioners, and others engaged or interested in the improvement of roads. There will be no laboratory fees or charges of any kind connected with the course.

A special announcement containing a complete program of the work will be issued about Jan. 1. Requests for copies of same should be addressed to John J. Cox, Assistant Professor of Civil Engineering, University of Michigan, Ann Arbor.

EXHIBITS AT THE ANNUAL ROAD SCHOOL OF THE WISCONSIN HIGHWAY COMMISSION.*

For four years the Wisconsin Highway Commission has held, in midwinter, what is known as the Annual Road School of the Commission. From the first, these schools have been successful, drawing from 200 to 500 persons to Madison to attend the various sessions.

This year the school will be held from Jan. 31 to Feb. 5, inclusive, at Madison, the sessions being held in the Assembly Chamber of the State Capitol. Owing to the fact that additional powers have been conferred upon certain county committees, consisting of three or five members in each county, and due to increased interest in the subject of road construction, it is believed that the Fifth Annual Road School will make a new high water mark in attendance and interest.

For three years the exhibits of machinery, etc., held in connection with the road school, more or less encouraged by the State Highway Commission, were a feature of the week, and resulted in both profit to those attending and to exhibitors alike. At the last year's school, due to a slight reduction in the amounts available for construction, and due to the fact that the counties were already well equipped, there was less interest in exhibits, and the State Highway Commission made no effort to secure them, rather to the contrary.

This year, however, there has been a considerable revival, and we find that there has been appropriated by the various counties for the purchase of machinery, tools, etc., probably as much as $180,000; so that there is again a considerable market, and a large part of the purchases will be delayed until the machinery at the road school is inspected, not to speak of purchases made by contractors and representatives of units of government other than counties who attend.

It would hardly seem necessary to have an exhibit of steam or gasoline rollers, or stone crushers, due to the fact that practically all counties are well equipped with these, and know about what they want if they are in the market. There are, however, probably going to be a considerable number of motor trucks purchased for hauling and maintenance purposes; possibly motor oilers; traction engines for road grading and maintenance; concrete mixers, especially small sizes; slips, wheelers, small tools, etc. There is going to be especial interest shown in motor trucks, devices used in road maintenance, oils and tars, oilers and oiling devices, and tractors.

The only space available for heavy exhibits will be the large open spaces in the streets off the capitol square. There will be room for a limited number of exhibits, such as literature and models, within the state capitol. No charge is made for space. We are not urging any company to make exhibits, but believe it fair to place the present conditions before all companies so that they may exercise their own discretion.

---

*Open letter from the Wisconsin Highway Commission to manufacturers of road-building machinery and materials.

Concrete Road Maintenance Practice, Wayne County, Michigan.—A crew consisting of seven men and a team provided with a tar kettle is used for maintenance work. The foreman is paid $5 per day, the team and driver $5 a day, tar man $3 a day, two laborers, $2.50 a day each, and two laborers, $2.25 a day each. The tools used consist of several wire bristle brooms, a wheelbarrow, a couple of shovels, and a tar bucket and sprinkling cans. Two men are utilized to sweep all cracks or spalled joints clean with the wire brooms, after which the man with the tar can fills the cracks with tar which is heated to about 225 degrees Fahrenheit, allowing it to stand for a few moments to prevent it from bubbling. It is then covered with a clean, coarse, dry sand, spread from a shovel. Pit holes are similarly treated. An excess of tar and sand is used and traffic is allowed to iron it out. Tarvia with a melting point of about 85 degrees Fahrenheit, a special mixture graded between Tarvia A and Tarvia X, is used. Where an imperfection exists that does not extend through the road but is over an inch in depth, it is cleaned and dried out carefully and painted with hot tar, after which it is filled with stone of a suitable size graded to fill the voids as nearly as possible, tamped down or rolled into place. Hot tar is then poured over the patch, the quantity being gaged so that the tar will be taken up by the remaining voids without any large excess being left on the surface, and coarse, dry sand is then spread with a shovel over the surface. Holes of a lesser depth and any joints from which the filler has wholly or partly disappeared come in for the class of treatment already described for cracks and joints. The maintenance crew will cover from 1 to 3½ miles of road in a day and one trip over the work yearly is usually all that is required.

CONSTRUCTION PLANT

BALANCED PISTON STEAM VALVE GEARS FOR IMPERIAL DUPLEX AIR COMPRESSORS.

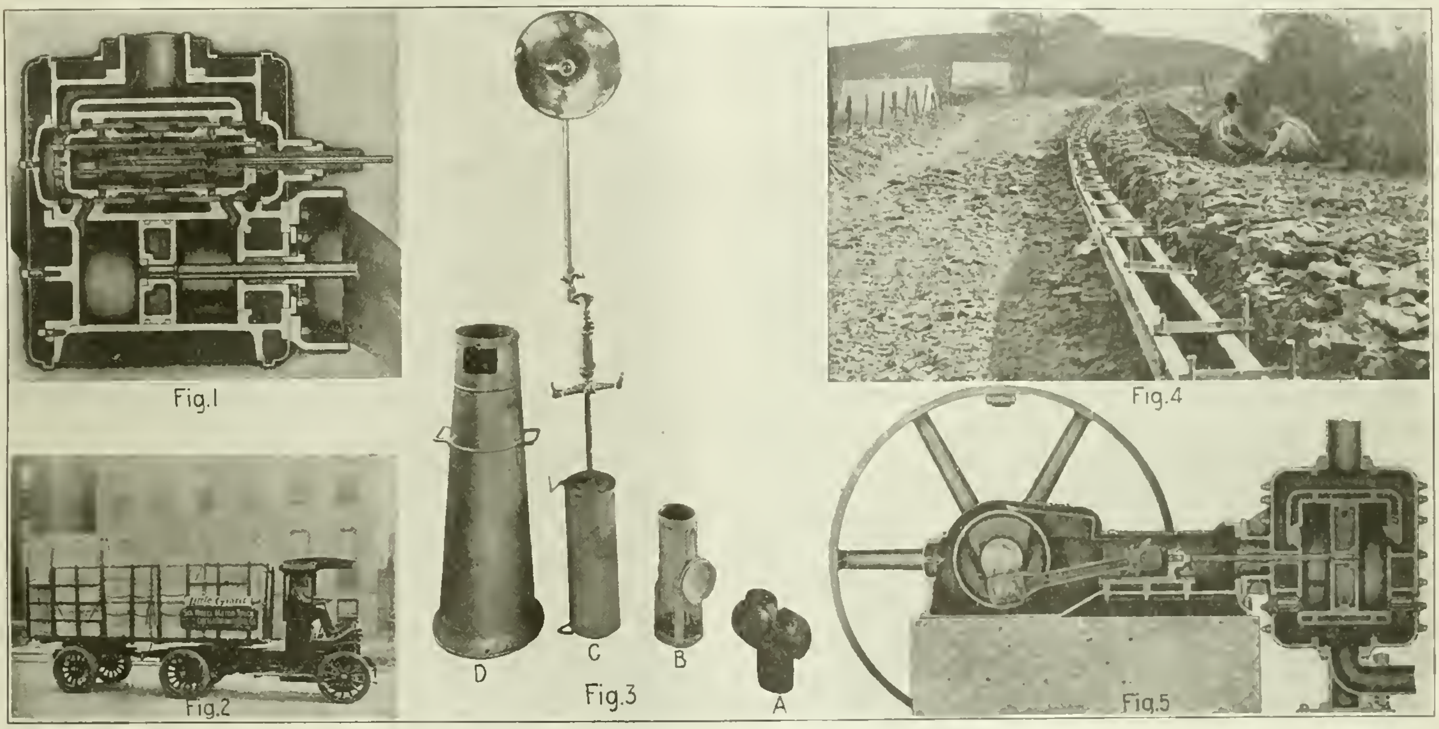
(Contributed.)

Present-day steam engineering practice is marked by the wider use of high pressure and superheated steam. This condition has made the use of the slide valve gear, even of the adjustable cut-off type, obsolete practice on steam driven air compressors. The slide steam valve in various forms has been standard on air compressing units below the sizes (about 24-in. stroke) where the use of the Corliss valve gear becomes commercially practicable. At high temperature the slide valve is very unsatisfactory, due to its tendency to warp, with consequent leakage. Under these conditions there is also an increasing difficulty of lubrication which results in greater wear and greater force required to drive the valve.

To provide a steam driven air compressor which will operate satisfactorily with high pressures and superheat as well as at more moderate pressures, there has been developed and perfected a balanced piston steam valve gear. This has been incorporated in the design of the standard Imperial duplex air compressors.

The use of the balanced valve makes it possible to control the machine in the only really economical manner—by automatically varying the point of cut-off in the steam cylinders. This method of regulation maintains constant speed for changing steam pressures and at the same time varies the speed of operation to the demand for air. Steam is always admitted to the steam cylinder at full boiler pressure and without the wire drawing of a governor of the throttling type, which means, in short, that the machine automatically operates at its highest efficiency. It is pointed out that the higher the steam pressure the greater the relative increase in efficiency.

With the hand adjusted cut-off valves, usually set at $\frac{5}{8}$ or $\frac{3}{4}$ stroke, the steam economy is admittedly poor, while with an automatic cut-off regulation the saving in actual steam consumption is the point most emphasized by the manufacturer.



NEW DEVELOPMENTS IN CONSTRUCTION PLANT.
Fig. 1—Balanced Piston Steam Valve for Air Compressors. Fig. 2—Six-Wheel Motor Truck. Fig. 3—Parts of New Carbide Flare Light. Fig. 4—Steel Form for Road Work. Fig. 5—Duplex Vacuum Pump with Corliss Valves.

This piston valve is a perfectly balanced valve of the telescopic type. The cut-off valves are right and left hand threaded to a cut-off valve stem. Steam admission is through the center of the valve, the steam then passing through the valve ports to the cylinder and then being exhausted by the ends of the valve. It is to be noted that this construction exposes the valve chest covers and steam packings to exhaust pressure only, proportionately reducing the liability of leakage. The design and even distribution of metal in the valve are claimed to preclude any possibility of warping and to result in a valve so balanced that friction is minimized and lubrication facilitated.

The steam ports are large and unusually direct and special effort has been made by the manufacturer to reduce the condensation surfaces in the cylinders. Exceptionally complete insulation, the separation of live and exhaust steam passages and the fact that the steam chest partially encircles the cylinder contribute to the steam economy. These points will be readily appreciated from the sectional illustration. The cylinder and receiver lagging is covered with a sheet iron casing and that of the cylinder heads with neatly fitting case covers.

The unique steam receiver is a direct connection between high and low pressure steam chests. The low pressure chest is proportioned to furnish additional capacity and so located that the heat ordinarily lost by radiation is used in heating the cylinder and valve. A special expansion joint prevents any possibility of cylinder alignment being destroyed.

The governor is a speed and pressure regulator which varies the cut-off by automatically rotating the cut-off valve stem and changing the relative position of the cut-off valves. It is essentially a chain driven rotary oil pump which acts against a weighted plunger. The variation in oil pressure due to the changing speed of the compressor, or the varying air pressure through the movement of the plunger, changes the cut-off point in the steam cylinders.

This governor is claimed to be entirely automatic in operation and capable of maintaining exceptionally reliable as well as close regulation.

Lubrication of both air and steam cylinders and valves is provided for by force feed oilers.

The other features of this new compressor, called by the maker "Imperial" Type XPV, are those of the "Imperials" now in service; wholly enclosed main frames containing the reciprocating parts, automatic lubrication by the bath system and the standard Imperial completely water jacketed air compressing cylinders.

This "Imperial" Type XPV compressor is a product of the Ingersoll-Rand Company, 11 Broadway, New York, and is built in capacities from 608 to 3,620 cu. ft. per minute and for discharge air pressures from 10 to 110 lb. per square inch.

A NEW SIX-WHEEL MOTOR TRUCK.

(Contributed.)

Industries having bulky or long but light loads to transport frequently fail to realize the expected economies of motor truck transportation owing to the very limited loading space which the ordinary chassis affords. In the ordinary four wheel truck the power is applied through its traction wheels and motor truck practice is to place the entire load or greater portion of it directly over or slightly forward of the traction wheels. The traction wheels must therefore both carry and push the load.

In the six-wheel truck shown by Fig. 2 these objections are overcome. The power of the motor is utilized to draw the load instead of carrying it and pushing it, with the result that efficiency of the power unit is doubled. In the six-wheel construction only sufficient of the load is placed upon the chassis of the truck to secure proper traction. But the weight so imposed is not rigidly fastened to the chassis but rests upon a ball race making it a live or floating load. This feature naturally relieves the running gear and engine from the shock and strain which a load ordinarily transmits to a truck as a result of the constant vibration due to irregularities of roadbed, and also affords relief from strain in starting and stopping. This relief from the shock and strain is so great that the life of the motor is naturally increased and has even been doubled.

In the six-wheel construction illustrated the rear wheels absolutely track and the driver need have no more concern for the movement and guidance of the load than in ordinary four-wheel construction.

The price of this new truck is low when compared to capacity. The amount of upkeep charges for maintenance, consumption of gasoline, oil, etc., is small. It is able to turn around in a 36-foot space, even when carrying lumber 40 ft. long. As an example of its speed, the truck made a trip from Philadelphia to Baltimore, 107 miles, including all stops, in 7 hours and 38 minutes.

The six-wheel construction is of such a nature that anyone owning a Little Giant Truck can purchase the additional outfit with all the apparatus necessary to complete the arrangement and easily apply it, thus making it possible by doubling the load space of the truck to double its carrying capacity.

This six-wheel truck is made by the Chicago Pneumatic Tool Co., Chicago, Ill.

A FLARE LIGHT USING CARBIDE CAKES.

In the light illustrated by Fig. 3 the carbide for gas generation is provided in the form of cakes or briquettes instead of in the usual lump form. The illustration shows the carbide cakes at A. At B is shown the cake holder into which the cakes are placed in charging. At C is shown the gas bell into which the cake holder is inserted. At D is shown the water tank in which the gas bell, with its attachments, is placed to complete the assembling of the light. The directions for operating and recharging the light are as follows:

To operate: Loosen the two clips and lift the gas bell, which contains the cake holder, from the water tank. Remove the cake holder from the gas bell by swinging the hook at the bottom of gas bell. Put one or more carbic cakes in the holder and return same to place in gas bell. (The number of cakes should depend on the probable time the light will be required to burn.) Replace the gas bell with cake holder in the water tank, fasten securely and open valve. Fill the water tank with water up to about 6 in. from the top, then light the gas. No additional water is required for the entire consumption of the charge.

To recharge: Shut off valve. Lift the gas bell from water tank and pour out residue and water. Never allow residue to accumulate in bottom of water tank. Then repeat instructions above. Do not throw away any pieces of carbic, no matter how small, simply place other cakes on top of the pieces, or use several pieces together. This light is made by the Carbic Manufacturing Co., Duluth, Minn.

A NEW VACUUM PUMP.

The illustration Fig. 5 shows a new vacuum pump recently placed on the market by the Ingersoll-Rand Co., New York City. In general design these new machines resemble this firm's Imperial Air Compressors.

The vacuum cylinders, as will be seen from the illustration, are somewhat different from those ordinarily met with. The intake valves are of the Corliss type, so placed in the cylinder head that the clearance is exceptionally low. This is considered a desirable feature in that the air trapped in the clearance spaces at discharge pressure will not reach such a volume, upon being expanded to intake pressure, as to greatly limit the pressure reduction which may be obtained. The action of the valve is positive and quick, and, its action being independent of the cylinder and intake pressures, the pressures within and without the cylinder are as nearly equal as possible.

The intake ports are large and direct, which together with the water jacketing of the valve tends to cool the intake gases. The discharge valves, which are of the "direct lift" poppet type, are placed in the bottom of the cylinder heads so that any entrained moisture or water is immediately discharged, a feature that makes for safety in handling moist or even saturated vapor. Clearance at the point of discharge has been reduced by making the valve partially fill the port in the cylinder head. The discharge passages are also water jacketed.

The cylinders are said by the manufacturer to meet fully the requirements of satisfactory and efficient operation. The air passages are unobstructed. The bolts pass from head to head and hold cylinder and heads tightly assembled. Both cylinder and heads are completely water jacketed, which is said to be an essential feature in the design of vacuum pumps, as the high ratios of compression tend to create high discharge pressures unless the heat is removed as generated.

The unusually low clearance in "Imperial" Vacuum Pumps has been obtained, not by dangerously close piston clearance, but by the correct design of the valves and valve ports. Owing to the extremely low clearance, the complete water jacketing, the use of mechanically operated Corliss inlet valves and other refinements of design the manufacturer guarantees the easy maintenance of a vacuum of within ½ in. of barometer.

The running gear, that is, the main frame with its enclosed reciprocating parts, the crank shaft, connecting rod, crosshead, valve gear and wheel on both belt and steam driven machines are of the same design as the Imperial air compressor. Lubrication is by the bath system, providing automatic flood lubrication yet retaining by the removal of covers from the casing all the points of accessibility of the open type of machine. When operating the fly-wheel is practically the only visible moving part, yet the entire mechanism is readily accessible while in motion.

The Imperial vacuum pump occupies less floor space than similar capacity machines of the straight line type, due to its duplex construction and to the fact that its speed of operation is higher.

In reality a Duplex machine such as this is two identical units of like capacity united by one common frame with cranks at 90 degrees. This makes it possible, should requirements fall temporarily below that for which the equipment was originally installed, to remove one connecting rod and the operation of one half the machine discontinued, while the other half operates at its rated speed and hence its utmost efficiency, displacing, however, one-half the vapor the entire machine is capable of handling.

These machines are built in capacities from 798-7048 cu. ft. per minute both for atmospheric and low pressure (5 lb.) discharge.

A NEW TYPE OF STEEL FORM FOR ROAD WORK.

The illustration, Fig. 4, shows a new type of steel form being used by the T. A. Gillespie Co., Pittsburgh, Pa., in the construction of six miles of brick road in Allegheny County. The form is so designed and standardized that the same form can be used not only on all sizes of curbing and combined curb and gutter, but also for concrete roads and sidewalks, as well as for edging for brick roads.

Each form consists of channels made of heavy pressed steel and is standard and made interchangeable. These units consist of 4-in., 5-in., 6-in. and larger sections. All sizes are units, built up to the required height by bolting one on top of the other. The T. A. Gillespie Co. made one equipment take care of all the work in the street and road field they had to do the entire season.

The illustration shows the form arranged for combined base and header construction for brick roads. The portable railway shown brings concrete and other material direct to where it is required from a receiving point several miles away.

The new form is made by the Blaw Steel Construction Co., Pittsburgh, Pa.

On the Newark, N. J., watershed, at a point attractive to tourists where autos frequently stop, a sanitary toilet has been provided and notices are posted appealing to people not to contaminate the watershed.

Engineering and Contracting

Devoted to the Economics of Civil Engineering Design
and to Methods and Cost of Construction

EDITORS

H. P. Gillette C. S. Hill C. T. Murray S. C. Hadden C. W. Malcolm

Volume XLV. CHICAGO, ILL., JANUARY 12, 1916. Number 2

REVIEWS OF CONCRETE CONSTRUCTION RECORDS.

The first of a series of reviews of concrete construction records is published in this issue. It discusses the concrete lining of tunnels by compressed air mixing and placing. The pneumatic process is, we believe, one of the great developments of the decade included in the life of this journal, in tunnel lining construction. The concreting problem in tunnel lining is carrying and placing concrete—the transportation of the concrete from mixer to forms. The pneumatic mixing and placing system is a distinctly successful proffered solution of this problem. Its development and the records it has made are well worth reviewing.

A QUOTATION, SOME QUESTIONS, AND A REQUEST.

An editorial in a recent issue of the New Republic, in commenting on the needs of America, says, in part:

> Nothing is so bad for the soul as feeling that is dispensed on nothing. * * * To feel and feel and feel and never to use that feeling is to grow distracted and worrisome, and to no end. We Americans have been witnessing supreme drama, clenching our fists, talking, yet unable to fasten any reaction to realities. Ferment without issue, gestation without birth, is making us sullen and self-conscious and ashamed.

There is so much of truth in the above statements that each of us may well study them carefully, in the hope that they may lead us to definite and well-conceived action. They are just as applicable to engineers and to contractors as they are to men engaged in any other kind of work. We do not hesitate to assert that more failures among employes are caused by a worrisome feeling that they are not being treated fairly, without taking proper steps—even in a small way—to correct real or fancied injustices, than to any other cause. We learn and we progress, or at least we take our rightful place among our fellow men, only by action. To what extent we succeed depends mainly upon two things: our knowledge and inherent ability, and the constructive action which we take to apply them to definite ends. Action requires courage; it also implies that the person initiating it is willing to assume added responsibility. With the man who possesses the qualities of great success it does more than this—it asserts a willingness to assume responsibility for mistakes made; and it is in this respect that the man of real ability differs from the failure.

To be more specific: Assuming that you are an engineer, with an honest conviction that you are not receiving proper returns for public service rendered, are you willing to assume your share in an educational campaign to convince the public that this is true? Or, if you really believe that the engineer must first improve himself—by making himself a better engineer and a better citizen—then are you willing to assert this?

At present there is much discussion of this and kindred subjects; but little action. As a class, engineers appear indifferent to any movement intended to secure wider recognition of engineering as a profession. Is there, then, truth in the belief—often held by men engaged in other lines of work—that the engineer is narrow, that his only interest lies in those things which engage his attention as an engineer? Moreover, is there truth in the assertion that the engineer works only for those ends which promise him definite and immediate remuneration? Again, is the profession of engineering, as generally recognized, overcrowded? The rapid decrease in the number of civil engineering students attending our technical schools seems to point to this conclusion, as regards this branch of engineering. A few prominent engineers—a very small number indeed—have evinced real interest in the present discussion of questions such as the above. Does it therefore follow that the remainder are satisfied that proper application and proper education (much of which must be gained out of college) are all that are necessary to achieve success in engineering? If this is true then those men who profess to see the need for some concerted action at this time are wasting their energy in worrisome effort, to no end.

We believe, however, the present movement has gained sufficient headway to justify some kind of action on the part of those engineers who heretofore have appeared indifferent to it; if for no other reason than to find out definitely where they stand. If those who are behind the movement are on the wrong track then the sooner they are made to realize this the better for all concerned. On the other hand, if you believe there is merit in the movement you owe it to yourself and to them to give active assistance to it. The editor of Engineering and Contracting will be glad to receive replies from engineers in answer to the following:

(1) Is there present need for a separate organization whose principal object shall be to secure wider public recognition of the engineering profession and to promote the interests of engineers?

(2) Can you suggest a plan of organization to which you would be willing to give active support?

PUBLICITY WORK BY CONTRACTORS.

Few contractors make skillful use of publicity methods. The manufacturer who produces a new machine or material advertises it. The engineer who designs a notable structure and directs its construction advertises it. The engineer does his advertising by a far different method than is employed by the manufacturer but it is none the less true advertising. A paper by an engineer published in the official journal of the local or national engineering society of which he is a member performs other and great service besides advertising the writer but it does advertise him. The best contributors to engineering society journals realize this fact completely and that they do is a factor which has helped toward their success. With rare exceptions the contractor advertises his performances in no way and he possesses just as good material for "copy" as does anyone in the engineering construction field. He can make his publicity appeal in quite as dignified a manner as does the engineer.

These comments have been suggested by a publication, which has come to our notice, issued by the Hardaway Construction Co., Columbus, Ga. The title of this volume is "Locks and Dam No. 17, Black Warrior River, Ala." The volume contains a description of the character and purpose of the improvement and a longer description of the construction processes and plant employed. Both descriptions were prepared by engineers engaged on the work. They are illustrated by plans and original photographs of the plant and structures and typical working operations. The volume is attractive. It is interesting to anyone concerned in engineering construction. It has a very distinct value in the engineering library. It is, finally, an exceedingly good advertisement of the capability of the contracting firm which publishes it. It represents the best sort of publicity work.

A number of the larger engineering-contracting-operating organizations like Stone & Webster and J. G. White & Co., are habitual practitioners of publicity work of the kind described. Aside from these few large organizations one has to search the remote corners of his recollection for an occasional other example. Is there not in this fact a peg on which to hang censure of the contractor as a business getter?

LECTURES TO WATER WORKS PUMPING STATION FIREMEN IN PHILADELPHIA.

During the spring of 1915 a series of notices or lectures was given to the firemen at certain pumping stations of the Philadelphia Bureau of Water. The information contained in the lectures was compiled from well known sources. There was an attempt, however, to present the matter in a way that would appeal to the average fireman. The results obtained were good.

There were five of these lessons on the theory and practice of combustion as applied to modern boiler room practice. In the first lesson combustion was defined and the content of soft coal was briefly discussed. The different stages of combustion were illustrated by means of a sketch. The second lesson took up the chemistry of combustion and defined an element, a chemical compound and a mechanical mixture. How chemistry is practically applied in the furnace was made clear. Reference was made to the fact that carbon monoxide was made by a local utility and sold for heating and lighting purposes at $1 per 1,000 cu. ft. and was, therefore, altogether too expensive to make and push out of the pumping station stacks. In the third lesson emphasis was given to the three essential conditions necessary for complete combustion: A thorough mixture of the gases, a sufficient air supply, and, a sufficiently high temperature in the fire box. The losses due to too much air were discussed. Certain points to remember in operating Wetzel stokers were emphasized. The fourth lesson told how the fireman could be sure he was maintaining the essential conditions for the complete and economical combustion of coal. The fifth and final lesson discussed the relative advantages of natural and mechanical draft and explained the uses and principle of draft gages.

The editors secured a copy of these lectures from Mr. C. E. Davis, chief of the Bureau of Water, with a view to their publication in our water works section. Although stated in the briefest terms they necessarily aggregate a considerable length and we hesitate to give space to them until assured of the interest in the subject by our readers. While we have doubtless given much more space to considerations of prime interest to water works operators than any other similar publication our articles have not dealt, except incidentally, with the boiler room end of water pumping stations. That phase of the literature of water works operation is usually, and quite properly, considered the domain of the mechanical engineering journal. As above indicated, however, we shall make an exception in this case if a sufficient number of our readers so request. Aside from their technical value the lectures are interesting examples of the instruction of employees in the proper performance of their duties.

THOMAS JEFFERSON, CITY PLANNER.

Thomas Jefferson was a many-sided man. Perhaps most of us think of him as having been a great lawyer, diplomat and statesman, as author of the Declaration of Independence, as Washington's Secretary of State and as third President of the United States. Then, too, he was founder of the Democratic party. In the light of all these accomplishments and achievements he is blessed by all good Democrats and damned, either with or without faint praise, by all good Republicans. Some of his lesser achievements are but little less interesting than those which are recorded in our school histories. For example, it is probably not generally known that he had a very keen interest in city planning and that he had much to do with planning the city of Washington. Mr. William Howard Taft recently called attention to this side of the many-sided Jefferson.

How Washington selected the site for the proposed capital city and how he engaged L'Enfant, an officer of engineers in the French army, to make a plan for the city of Washington is a story familiar to all. Jefferson had much to do with the planning. Not only was he a very skilled architect, but he had a very lively curiosity and interest in the planning of cities.

Mr. Taft reminds us of the fact that Jefferson represented the United States as a diplomat in the negotiations with France and other European countries during and immediately after our war for independence. His duties naturally led him to visit many cities, and he got the plans of every city he visited. He studied these plans and, later on, turned them all over to L'Enfant. L'Enfant took these plans and upon them as a basis made what is really the present city plan of Washington. Washington is to become, in the development of this plan, the most beautiful city in the world.

These facts are recorded for the interest of our readers quite as much as to bolster up, if only slightly, the fame of Jefferson who, because of being a small navy man and the original Democrat, is not always spoken of with proper consideration in these days.

A HINT FROM AUSTRALIA ON THE USE OF TECHNICAL JOURNALS IN ENGINEERING COLLEGES.

At the University of Queensland, Brisbane, Queensland, Australia, there is a seminar course for the fourth year engineering students. In this course the senior civil, electrical and mechanical students meet jointly at times and separately according to their several specialties at other times.

Each student is assigned three or four technical journals and one or more numbers of technical society proceedings, along the line of engineering in which he is especially interested, and it is his duty to read these as they are received and to make formal report of their principal contents. He is furnished printed form index cards and makes out a card for every article or society paper which he considers of sufficient importance to index. Each card bears, among other things, the title, source, and date of the article and a brief digest of its contents. These cards are made in duplicate. The student retains one card and the companion card is filed in the appropriate card index maintained by the University. These cards are prepared outside of the time allotted for the subject on the program and the filled in cards are brought to the class. The student reads them to the class and amplifies the recorded digest of the contents in an oral statement. He must be prepared to lead a discussion of the article if one develops. On this part of the work all the senior engineering students meet together and the civil engineer learns what is going on in the electrical and mechanical engineering fields. This broadens his outlook and is a valuable feature of the course.

In addition to the work described each member of the class writes and reads papers from time to time along his own line to the segregated classes.

The plan is commendable in its entirety. The engineering student should be given formal instruction in the use of the technical journal. It is not enough to advise him to read such journals for only a few will follow such advice. Such reading should be prescribed and wisely directed. Especially is the plan good if it fairly covers the field of technical journals—all should be mentioned and all investigated. Many professors of engineering are content to name one or two journals which were, perhaps, companions of their youth and of which they have at present scarcely more than a traditional knowledge. They are ignorant of or indifferent to the merits of younger journals. This procedure is comparable with the tendency of the man in the street to name Harvard and Yale Universities as the only first class institutions of higher learning in the country. One tendency is as ridiculous as the other.

GENERAL

TUNNEL LINING BY COMPRESSED AIR MIXING AND PLACING.

I.

Pneumatic concrete mixing and placing is a comparatively recent development in construction processes. A period of about three years covers all actual experience with the process in concrete tunnel lining construction. In this brief time, however, the development has been rapid and the process has attained an acknowledged and important place. Some score and a half at least of tunnels have been lined with some form of apparatus for mixing and placing concrete by compressed air. The results have been successful and have improved with experience. Consideration of the method is warranted by its considerable use and general success and separate consideration is warranted by the sharp distinction between it and all other methods employed. The method and the apparatus are controlled by patents, which also makes separate consideration desirable. Patents are controlled by the Concrete Mixing & Placing Co., Chicago.

General Description.

The pneumatic method of mixing and conveying concrete depends upon adiabatic expansion of compressed air. The materials for a batch of concrete are placed unmixed in a chamber which has leading from it a discharge pipe. The chamber is then sealed at the top and compressed air is admitted to blow the charge through the discharge pipe to the place of deposit. The mixing is performed in the chamber and in the discharge pipe. More precisely, in tunnel lining, the charging chamber, or "mixer," is located at a suitable point outside of or within tunnel and from it the discharge pipe extends a distance to the centers or forms for shaping the lining.

Details of Apparatus.

The apparatus required consists of three main units: (1) The mixer; (2) the compressed air plant; (3) the concrete conveying pipe system.

Mixer.—The mixer consists of a steel shell having the shape of an inverted cone, surmounted by a small cylindrical chamber as shown by Figs. 5 and 6. The top of this cylindrical chamber is closed by an air cylinder operated flap door, and connected to the bottom of the conical chamber is a 90-degree elbow to which is attached the discharge pipe. The door is the only moving part of the apparatus. Also the interior is entirely smooth. As stated previously the mixing process occurs both in the mixer and in the conveying pipe.

The mixing air jet is located in the elbow at the bottom of the mixer, the air stream being directed along the center line of the discharge pipe. The air from this jet strikes the material as it falls from the cone-shaped chamber. The mixing jet is also the conveying jet; it furnishes the air for blowing the concrete through the discharge pipe. There are also air jets in the upper part of the mixer which are solely for creating pressure to force the charge of materials downward into the discharge pipe where the mixing and conveying jet can act on it. The piping system by which the air is directed to the various named places of performance is shown by Fig. 5. Only the main elements are given further mention.

To admit air into the mixer, two main valves are used; one admits air through the jets in the upper part of the mixer, and the other admits air to the jet in the elbow. In operation the air is admitted first to the lower or elbow jet and then immediately to the jets at the top of the mixer. Two gages show, respectively, the pressure of the air supply and the pressure in the mixer during discharge. As soon as the charge has left the mixer the top jets are closed; the bottom jet is closed as soon as the mixer gage shows by dropping to zero, which it does gradually, that complete discharge has been effected. The charging of the mixer involves no special manipulations.

Compressor.—A suitable type of compressor and the one usually employed is a straight-line, one or two-stage machine compressing to 80 to 100 lbs. The motor power may be steam, gasoline, oil or electricity, as is most economical under the conditions prevailing. It is desirable to install the compressor as near as possible to the mixer; this reduces friction and loss of pressure. Another feature of importance is the provision of storage tanks of a capacity equal at least to all the air required to mix and eject one batch. Approximately, the storage capacity should be 30 cu. ft. per 100 ft. distance of discharge. This is a rule-of-thumb estimate which practice in a number of installations using a ½-cu. yd. mixer has proved satisfactory. The compressor then must be able to supply at from 80 to 100 lb. pressure the quantity of air indicated. Up to 600 ft. discharge one batch per minute can be mixed and placed; beyond this distance the time of discharge renders one batch per minute impossible.

Discharge Pipe.—Any standard pipe may be used for discharge pipe, but the best for most conditions is well casing, weighing about 17 lb. per foot, with Van Stone joints. The most rapid wear occurs at bends or elbows. An ordinary pipe bend will wear through in passing 500 or 600 cu. yd., then patched will pass another 500 to 600 cu. yd. Cast manganese steel elbows are used whenever possible; 12,000 cu. yd. of concrete have been carried by manganese elbows without wearing through. Either 6-in. or 8-in. pipe is used, depending upon size of coarse aggregate and upon amount in a batch. For a ¼ cu. yd. mixer using 1-in. stone the 6-in. pipe is adequate; for a ½ cu. yd. mixer using 2½-in. stone an 8-in. pipe is required. Any pipe used must be smooth inside and have joint connections easy to make. Where a branch pipe is desired a Y is used with arms departing about 22½ degrees from the main pipe. In the Y a sliding plate gate deflects the concrete to either arm desired.

Selected Examples.

In the preceding outline only the separate units of a pneumatic mixing and placing plant are considered. The manner of assembling these units into an operating plant will vary with conditions. Illustration is best made by selected examples, and a number of these follow:

Water Supply Tunnel at St. Louis.—From a shaft 96 ft. deep the river tunnel extended 2,300 ft. and the shore tunnel extended 560 ft. The lining was 1:2:4 concrete 8 to 20 in. thick. The mixer was of the type shown by Figs. 5 and 6 and was of ¼ cu. yd. capacity; the discharge pipe was 8 in. in diameter. The shore tunnel was lined complete by pneumatic placing, but the invert of the river tunnel was concreted by hand and only the arch and sides by pneumatic placing.

For lining the shore tunnel the mixer was set at the shaft bottom, Fig. 4. Measured materials were placed in a hopper, with a bottom slide door at the shaft top; from the hopper bottom a 10-in. pipe descended vertically to the mixer. At signal the hopper charge was dumped into the mixer. At first water was added at the hopper; this caused clogging in the pipe and later a 2-in. water pipe was carried down shaft and the water added at the mixer. The concreting procedure was generally as follows:

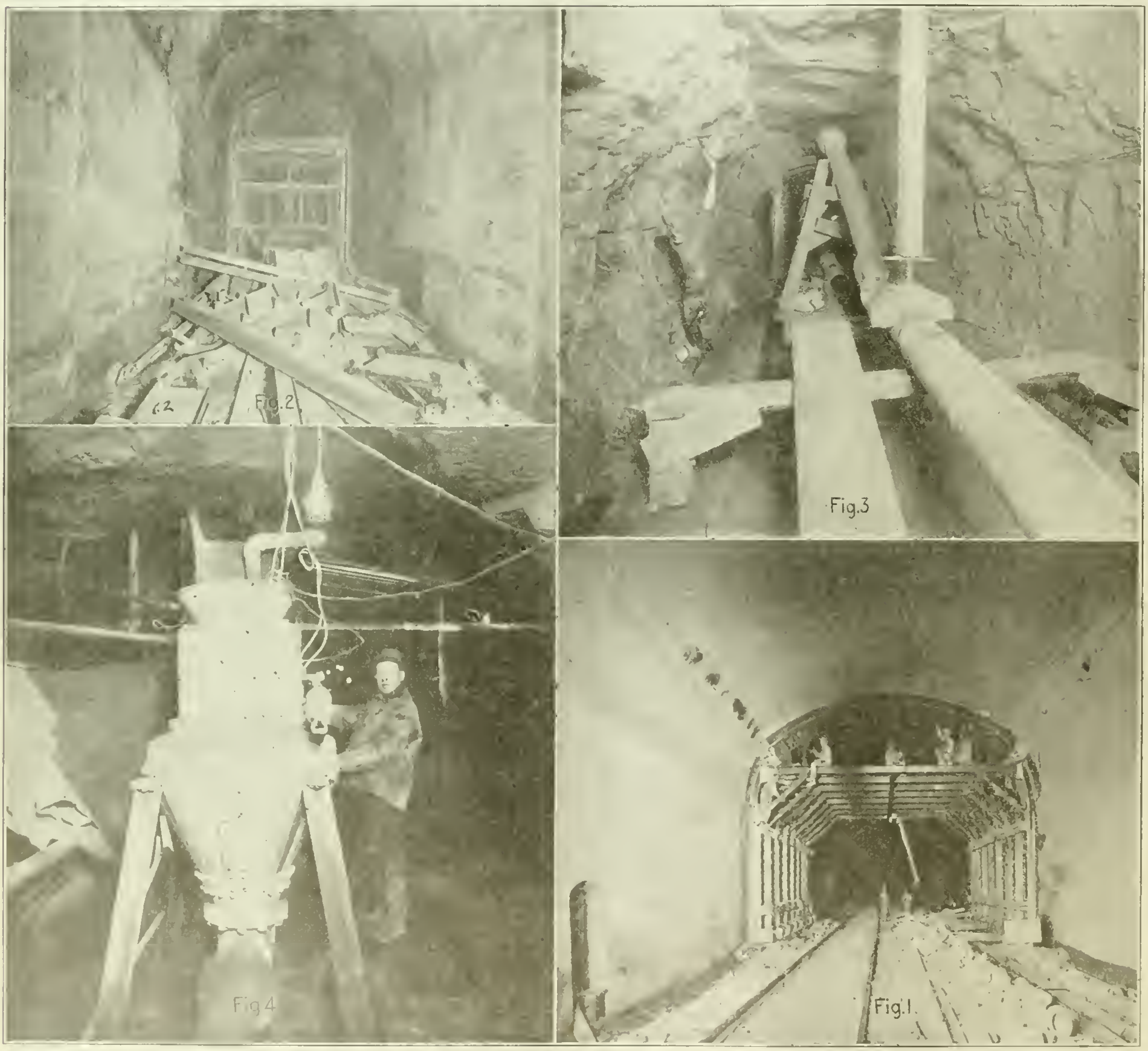
One set of forms 36 ft. long was set up approximately 70 ft. from the far end of the tunnel. The 8-in. discharge pipe was laid through the forms, and concrete was placed for 70 ft. of invert. After this section of invert was placed, the track was laid at the proper elevation, carefully centered, and the forms were pushed back over the completed invert and made ready for concreting the arch. Heavy bulkheads were built at both ends of the arch with sandbags. The discharge pipe was laid from the mixer to within 20 ft. of the forms and here an elbow of 22½ degrees was inserted. Then a 20-ft. length of pipe was added, which brought the discharge pipe up to the roof of the tunnel, and here another $22\frac{1}{2}$-degree elbow was placed, Fig. 3. Then a piece of galvanized pipe about 18 ft. long was placed, which carried the end of the pipe over the forms to about the middle. This pipe was easily handled and placed, but had to be renewed every third day.

For concreting the arch and side walls of the river tunnel, with the air capacity available, it was decided not to shoot the concrete more than 1,100 ft. The mixer was moved to a point approximately midway between the shaft and the end of the tunnel, and placed in a hole 4 ft. deep so that the top of the machine was approximately 18 in. below the center of the tunnel. The tracks were elevated on a platform.

The material for concrete was measured in the hopper and was dumped through a 16x16-in. chute into side dump cars and hauled directly over the mixer. A 1-in. pipe delivered water directly into the mixer. Two sets of forms were set up, one 1,100 ft. from the machine, and the other 500 ft. from the machine. The discharge pipe was elevated 3 ft. above the invert so that it would run through the first set of forms and not interfere with the moving.

The first effort to shoot concrete into the forms at the end of the tunnel was a failure and two air receivers (125 and 100 cu. ft. capacity) were placed in the tunnel at the mixer; little or no trouble was then experienced in shooting the concrete the required distance. The forms were poured alternately, requiring from two to four hours, depending upon the distance between the mixer and the forms. A perceptible difference in the quality of the concrete at the rear and the front of a form was noticed. Investigation showed that the gravel in the concrete was discharged at a high velocity and deposited in the rear part of the forms, while the mortar would drop almost directly from the end of the pipes about midway of the forms. To overcome this, a 10-in. galvanized pipe 12 ft. long was slipped over the 8-in. discharge pipe leading from the end of the arch to the center. This pipe was made loose, so that as the forms were filled it could be slipped back, thus keeping the end of the discharge pipe no more than 4 ft. from the place where the concrete was being deposited. This device proved quite effective, and the quality of concrete was more uniform throughout the form.

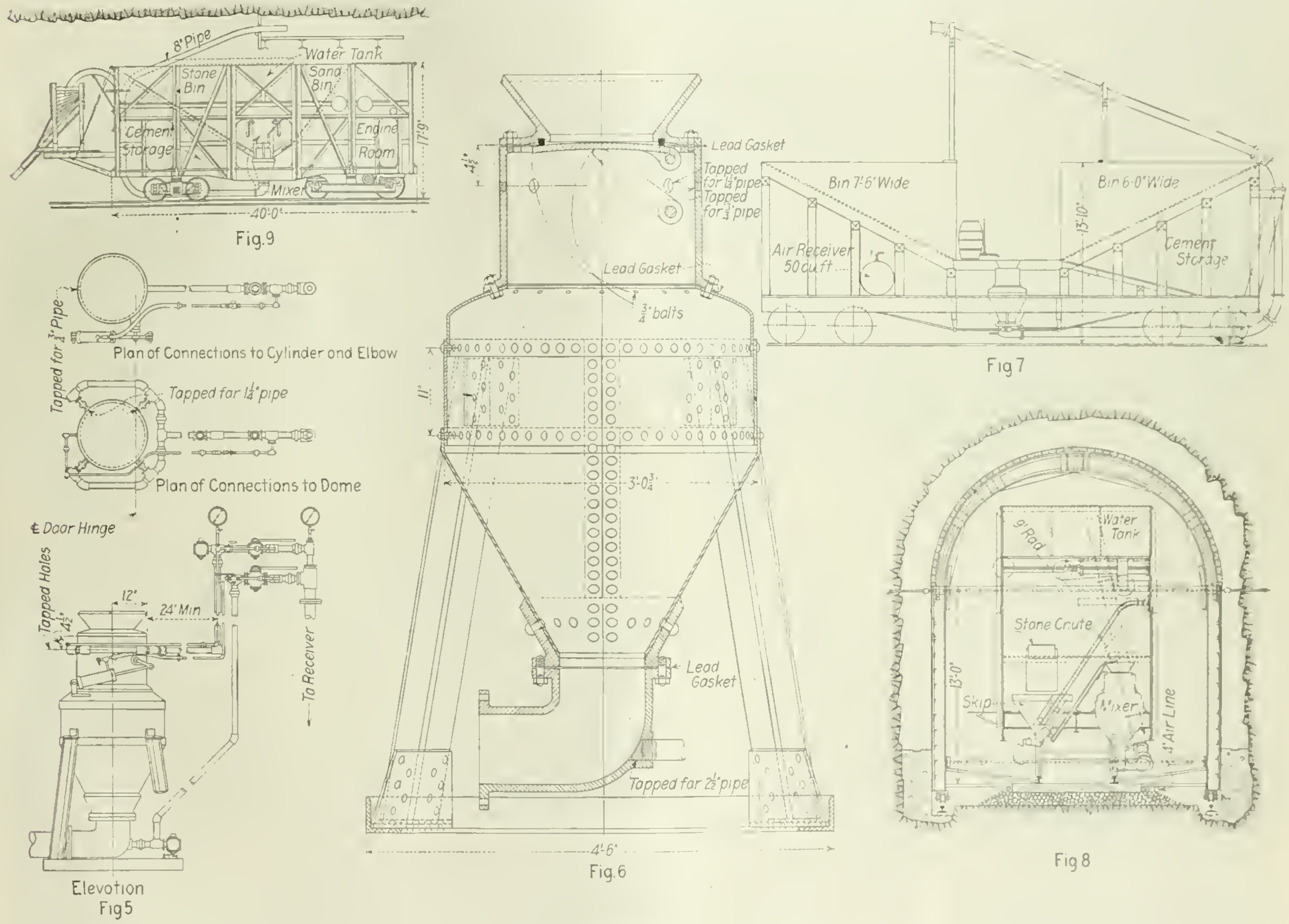
After the part between the mixer and the end was completed, the mixer was again moved to the bottom of the shaft. One set of forms was pulled ahead on the track to a point 500 ft. from the machine, and the concreting



VIEWS OF TUNNEL LINING BY COMPRESSED AIR MIXING AND PLACING.
Fig. 1—Diana Tunnel, Showing Lining and Forms. Fig. 2—Arminto Tunnel, Showing Lining and Forms. Fig. 3—St. Louis Water Tunnel, Showing Pipe Rise Into Forms. Fig. 4—St. Louis Water Tunnel, Showing Mixer in Tunnel.

was handled in the same manner as in lining the shore tunnel.

The shore tunnel lining arch and invert was completed in 20 working days (416 lin. ft. in 20 days), or at the rate of 22.3 lin. ft. per day. In the river tunnel 2,167 lin. ft. (excluding invert) were lined in 50 working days, or at the rate of 43.4 lin. ft. per day. In this tunnel, however, two sets of forms were used and poured alternately; the forms were pulled from 12 to 16 hours after being poured, and in a great many cases two arches were poured in 24 hours. Each form held from 100 to 125 batches, each batch consisting of 1½ sacks of cement, 3 cu. ft. of sand and 6 cu. ft. of gravel, making approximately 40 cu. yd. The concreting force employed depended upon the number of arch sections poured per day. The average force consisted of: 1 superintendent, 1 compressor engineman, 1 fireman, 2 men loading materials from the cars to the storage yards, 4 to 5 men wheeling material from the storage yard to the hopper at the top of the shaft, 1 motorman (who also took care of the gang of 2 to 3 men doing odd jobs and maintaining the track), 1 foreman and 6 laborers moving forms and adjusting the discharge pipe preparatory to concreting, 1 man on the forms while the concrete was being poured, and 1 concrete finisher.



SKETCHES OF PNEUMATIC MIXERS AND MIXING PLANTS FOR TUNNEL LINING.
Fig. 5—Sketch of Mixer, Showing Piping and Valve System. Fig. 6—Section of Pneumatic Mixer. Fig. 7—Mixer Car for Lining Arminto Tunnel. Fig. 8—Section of Sandy Ridge Tunnel. Fig. 9—Mixer Car for Lining Sandy Ridge Tunnel.

The following observations were made during the work: The blown stream of concrete striking rock projections from the roof would split and leave a void behind the projection. The amount of air consumed varied from 1.2 to 1.7 cu. ft. per lineal foot of discharge pipe.

Sandy Ridge Tunnel, Virginia.—The tunnel is 7,804 ft. long, located on the Carolina, Clinchfield & Ohio Ry. near Dante, Va. The lining involves placing 50,000 to 60,000 cu. yd. of concrete without interrupting train service. The following is a description of the plant being used and a statement of such records as are at present available.

The mixing plant is mounted on a car 40 ft. long, 10 ft. 4½ in. wide and 17 ft. 9 in. high, built of steel as shown by Fig. 9. The car has a central chamber, open on all sides, 8½ ft. long, 9 ft. 8 in. wide, and 10 ft. 3 in. high, in which is located on one side the mixer and on the other side the charging skip. Over this chamber is an 1,850-gal. water tank. Facing the central chamber is the stone bin of 30 cu. yd. capacity on one end, and the sand bin of 12 cu. yd. capacity on the other. Each bin has a chute 20 in. wide leading to the charging skip, and each chute is controlled by an under-cut gate. Under the stone bin is space occupied by a 96-cu. ft. air receiver standing vertically, and also a space for the storage of cement in bags. Under the sand bin are the gasoline engine for propelling the car, and its auxiliary equipment. The charging skip in its lower position stands with its top rim about 15 in. above the floor, and it travels on inclined guide rails to its upper position over the mixer, being hoisted by a compressed air cylinder of 9¼ in. diameter. The gate of the skip works automatically by means of a guide rail.

The mixer is for a two-bag batch (4-10 cu. yd.) and has its 8-in. outlet pipe at the bottom running horizontally and curving to the outside of the rear truck and thence vertically to near the top of the car, where it branches by means of a Y into two lines, one an 180-degree bend to the rear for concreting foundations and sidewall, and the other going to the rear for shooting into the arch.

The compressor plant is located near the tunnel portal and has two compressors with a capacity of 375 cu. ft. of free air per minute; they compress to 115 lb. From the compressor a 6-in. pipe leads to a 150-cu. ft. air receiver and thence a 4-in. pipe line goes on a 0.5-per cent down grade through the tunnel. At the lower end is a pet cock to drain off any water. To care for expansion and contraction the pipe line is laid alternately on the east and west sides of the track in lengths of about 1,000 ft. and connected by curves of 2-ft. radius. The bottom of the pipe is level with the bottom of the ties, 1 ft. from their ends. About every 100 ft. a long radius tee is placed, and about 20 mine cocks of 24 in. are provided, which can be shifted to the various tees as the progress of the work demands. To any of the mine cocks a 3-in. hose may be connected from the 96-cu. ft. air receiver on the car, and in this way with a hose 60 ft. long the car can be connected to the 4-in. pipe line at any point at which it may stop.

In operation the car receives its load by gravity from outside storage bins and tanks; it then runs into the tunnel to the place of concreting, is connected up and mixes and places its load of materials. The forms are of steel, with the exception of the arch ring, which is 3-in. hard pine on steel ribs. They are of the Blaw collapsible type, and of exceptionally stiff design. They are held by anchor bolts to the walls of the tunnel, and are without interior bracing, rods or struts, so that the concreting car as well as trains may pass without interruption. They are collapsed by means of turnbuckles on rods temporarily inserted as shown in Fig. 8. Five 30-ft. sections are provided. For the foundations and initial bench wall wooden forms are in use. They are made in 12-ft. sections and braced from the track.

The work done at the time the data here were reported had consisted altogether of side wall to about the height indicated by Fig. 8, and is thus not representative, but the following tabulations are indicative: Table I. shows the weekly output of concrete in place, and Table II. shows the time record for five consecutive days.

TABLE 1.—CONSTANTLY INCREASING WEEKLY YARDAGE.

Week ended—	Yardage.
July 17	261
July 24	379
July 31	516
Aug. 7	822
Aug. 14	928

Diana Tunnel, Tennessee.—This tunnel is 1,520 ft. long and is located on the Louisville & Nashville R. R. The mixer plant of standard equipment previously described was located first at one portal and then at the other. Full section steel forms (Fig. 1) of the Blaw type were used. The significant records of the lining work follow:

It was found that the 8-in. pipe used wore out first at the joints as the pipe was thinnest there on account of the threads. One thousand feet of standard pipe was purchased at the beginning of the work, and after the work was half completed 300 ft. of well casing with Van Stone joints was purchased. This well casing was found to be well adapted and did not give trouble through wearing at the joints as did the standard pipe. Another advantage of the Van Stone joints was their flexibility, as about 5 degrees deflection could be obtained in this joint without a strain on the flange. Of the entire amount of pipe purchased, which was bought second hand, about half was still in very good condition at the close of the work after having some 11,000 cu. yd. of concrete blown through it. The elbows used consisted of cast manganese steel and also of bent pipe. The manganese steel elbows were purchased at the beginning of the work and were still in good shape at the end, having shown very little wear. The manganese steel elbows were, however, very heavy, weighing about 400 lb. for a 90-degree bend, and for this reason the pipe bends were used over the crown of the arch where handling pipe was difficult. The pipe bends weighed about 125 lb. each and were worn through on the outside of the curve, and when worn through a "half sole" or patch was clamped over the worn part which usually lasted for another 500 cu. yd.

At the beginning, the engineers permitted the moving of the forms after six days, but after a time this period was reduced to four days. In all there were 41 form sections, each approximately 35 ft. long and containing about 250 cu. yd. in each section. The longest distance which concrete was transported was 925 ft. and the average distance was about 400 ft. The average time to concrete one 35-ft. section was approximately 24 hours, although some forms were filled in 15 hours. The number of men required to mix and place the concrete was 13, including 3 men in the bins, 1 operating the gate levers, 1 to level off the measuring hopper containing the batch, 1 man on cement, 1 mixer operator, 1 man on the conveyor pipe, 1 attending to the bulkheads and 1 foreman and 4 men helping in the forms. A gang of 10 men was employed constructing footings and to move and set the forms.

Arminto Tunnel, Wyoming.—The work consisted in placing 5,878 cu. yd. of concrete in 745 lin. ft. of lining of a timber-lined tunnel of the Chicago, Burlington & Quincy R. R. The tunnel was 16 ft. wide and 30 ft. high inside, with lining 2 ft. thick. The section is indicated by Fig. 2, which also shows the type of forms and the concrete surface finish as left by the forms.

Water in tank cars, gravel, cement and all other material had to be hauled in by railway. The stock piles and power plant were located on one side of the approach cut near one portal. At first the compressor used was an Ingersoll-Rand, two-stage, belt-driven machine operated by a 21 hp. gasoline engine; the 92 cu. ft. of free air per minute was too small. Later, addition was made of six Westinghouse 9½-in. air pumps, which increased the capacity to 200 cu. ft. of free air per minute. In the fourth month of work the air pumps were replaced by a Leyner compressor and the capacity was increased to 335 cu. ft. of free air per minute, which is about the capacity that should be provided for the mixer plant used.

The mixer plant was car-mounted as shown by Fig. 7. On this car the cement was stored in bags under one of the bins and discharged toward the center of the car through chutes into a measuring hopper. The measuring hopper was lifted and tilted automatically to discharge into the ¼ cu. yd. mixer. The lifting device consisted merely of a 6-in. air cylinder. The 8-in. delivery pipe led from the mixer under the car and vertically up at the end to the crown of the arch, where a 90-degree elbow entered through the bulkhead of the form. Air was supplied from the compressor plant at the mouth of the tunnel through a 4-in. main laid on brackets fastened to the timber posts and a connection was afforded from this main to the air receiver on the car by means of a hose. The car was taken into the tunnel by means of a dinky engine and spotted at a point next to the forms. The upper elbow of the delivery pipe was previously suspended in place so that when the car was spotted the upper pipe was bolted to the pipe on the car, which came directly under it. The air connection was then made and concreting begun.

TABLE II.—RATE OF DISCHARGE OF BATCHES.

Date.	Batches.	Minutes.	Average, Sec. per batch.
Aug. 17	423	381	54.0
Aug. 18	323	302	56.1
Aug. 19	448	340	45.5
Aug. 20	325	250	46.1
Aug. 21	309	280	54.3

Besides the concreting car, there were a derrick car, tank car, flat car and dinky engine, whose service was charged into the work by the railway.

The work of lining occupied from in July, 1914, to in February, 1915, and some general records follow:

Cu. yd.	Lin. ft. concreted.	Cu. yd. per lin. ft.	Minutes per batch.
127	15	8.4	7
295	45	6.6	2
551	80	6.9	2
765	100	7.7	1½
1,103	140	7.9	50 sec.
874	100	8.7	45 sec.
1,491	175	8.5	50 sec.
672	90	7.5	50 sec.

The average cost per cubic yard of concrete in place was about $6.80, of which about $3.45 were labor cost. Taking the highest month's output, 1,491 cu. yd., when no exterior delays of any consequence occurred, the cost of mixing and placing may be figured as follows: 7,964 batches times 50 seconds equals 6,636.6 minutes equals 110.61 hours times nine men on cars equals 995.49 man hours times 25 ct. equals $248.87 divided by 1,491 cu. yd. equals 16 2-3 ct. per cubic yard.

Discussion.

A review of the selected examples enables one to arrive at several broad general conclusions of value, and these may be supplemented by others furnished by tunnel lining work not listed in this article. It has been proved beyond question that as a means of lining tunnels with concrete the compressed air method has a sure position. Incidentally the application of the method is not limited to tunnel lining, but the present discussion is restricted to tunnel work and further mention of other kinds of work will not be made.

Location of Mixer.—Generally speaking the location of the mixer should be as near the place of concreting as possible, having due regard to suitable length of discharge pipe. As mentioned previously a part of the mixing process takes place in the discharge pipe and the length of this pipe must therefore be sufficient to complete the mixing process. It is assumed as an approximation that 50 ft. of discharge pipe are necessary. At Sandy Ridge tunnel 40 ft. of discharge pipe was employed at times and no defect of mixture was observed. These lengths of discharge may then be accepted tentatively as necessary. The upper limit of length of discharge pipe is determined by relative costs. Practice records lengths up to nearly 2,800 ft. Generally speaking, length of discharge should be kept well under 1,000 ft. to obtain the best results in comparative output and costs. So much for location of mixer with respect to horizontal distance from the place of converting.

In level the location may within limits be, without detriment to results, considerably either above or below the point of depositing. A rise of pipe of 15 to 20 ft. above mixer level is common experience. There are frequent examples of rises of 20 to 30 ft. In experiments concrete has been deposited 100 ft. above the mixer. Probably these are not the extremes, but they indicate generally the limits of location of mixer below the point of deposit. Location above the point of deposit is rare in practice. At Tallulah Falls tunnel, however, one mixer was located at the shaft top and operated successfully.

The ideal location of mixer for tunnel lining, and particularly for lining railway tunnel, would seem to be on car as at Sandy Ridge and Arminto tunnels. With an air main through the tunnel supplied from an outside compressor plant, a car mounted mixer gives remarkable flexibility of lining placing operations to meet traffic conditions and other operations facilitated by ability to clear the tunnel of obstructions, besides affording direct deposition, quick shifting of work, and a minimum of pipe handling.

Discharge Pipe.—Size of discharge pipe in relation to capacity of mixer has an important bearing on rapid and economic operation, but ordinarily this is a problem that need not concern the user. As made by the companies controlling the process, mixers are given the discharge openings suited to their capacities. Wear of pipe, pipe alinement and pipe handling are however distinctly users' problems and the troubles they may cause unless their solution is known are many.

Pipe wear is a serious problem. Driving a batch of concrete through a closed pipe under crowding pressure at a speed of a mile a minute is a severe abrasive test. Practice furnishes rather erratic records of pipe wear, because in the past no uniform practice existed in quality and make of pipe used or in the character of the joints. Always, naturally, alinement varied and especially the amount of curvature and the number of curves. At Tallulah Falls tunnel spiral riveted pipe was first tried, but the lines of rivets caused rapid wear and frequent ruptures. On the Stockton and Twin Peaks tunnels in San Francisco studies of pipe wear gave the following facts: An 8-in. steel pipe was used and 16 cu. ft. charges were shot under 120 lb. air pressure with velocities of 75 to 100 ft. per second. On level straight line ordinary 8-in. flanged connection steel pipe not quite new had a life of about 6,000 cu. yd. of concrete conveyed. The same pipe on an up-grade of 7 per cent wore through first on top. Threaded connections proved least durable; the thinning of the section by threading resulted in rapid cutting through at the joints. At bends, 4 ft. radius, ½-in. steel pipe cut through in instances in 12 hours continuous conveying and averaged only 60 hours' life. As a remedy cast manganese steel elbows were adopted and despite their greater expense proved more economical than ordinary steel elbows. The influence on wear of velocity and pressure of flow has been mentioned. Another influencing factor is the character of the coarse aggregate. Pit run gravel causes least wear, broken stone causes more rapid wear and slag causes extremely rapid wear.

The causes named for excessive wear indicate the remedies to be adopted. A straight alinement is the first remedy. Such alinement is also desirable because it reduces friction and so saves air. Instead of even upgrade rises use elbows; this confines unusually rapid wear to short sections. When the amount of concrete to be handled is considerable substitute manganese steel for elbows. Have no projections inside the pipe; it should be absolutely smooth. Use a form of connection that makes the joint inside smooth and even and does not reduce the thickness of the shell. For convenience in handling the joint connection or coupling should be one that can be quickly and easily made in restricted space.

Air Consumption.—The amount of air consumed depends upon the specific gravity of the aggregate, size of pipe used, size of storage tank, horizontal and vertical distances of discharge, kind of pipe, number of bends in the discharge pipe and principally upon the operator. Table III gives the theoretical capacities for continuous operation at various horizontal distances.

The figures in Table III are based on observation for the shorter distances of discharge and are computed for the longer distances. At the St. Louis waterworks tunnel the air consumption was from 1.2 to 1.7 cu. ft. per lineal foot of discharge pipe. At Richmond Tunnel, San Francisco, the consumption was 1.3 cu. ft. per lineal foot of pipe. Another tabulation given by H. A. Leeuw and stated to be based on three years' study and experience, is Table IV.

TABLE III.

Distance, ft.	100	200	500	800	1,000	1,200	1,500	2,000	2,500
Time of shooting	10	15	25	40	50	60	75	100	125
Time of loading, secs.	20	20	20	20	20	20	20	20	20
Time per batch, secs.	30	35	45	60	70	80	100	130	145
Batches per min.	2.0	1.8	1.3	1.0	.85	.75	.6	.46	.41
Batches per hour	120	108	78	60	51	45	36	27	24
Yards per hour	40	36	26	20	17	15	12	9	8
Actual free air required, cu ft. per min.	400	720	1,300	1,600	1,700	1,800	1,840	1,840	2,000
Size of air reservoir, cu. ft.	50	100	150	240	300	360	450	500	750

TABLE IV.—CUBIC YARDS OF CONCRETE PER HOUR, MIXER CAPACITY ½ CU. YD.

Actual amount of compressed air required. Cu. ft. of free air per minute.	Length of horizontal discharge.					
	100 Lin. ft.	300 Lin. ft.	400 Lin. ft.	600 Lin. ft.	800 Lin. ft.	1,000 Lin. ft.
600	20	15	10	..	..	..
800	30	20	18	12	6	..
1,200	40	30	25	20	12	8

Time Studies.—Tables V and VI give two time studies which were made during the course of a regular day's run on one job. The air supply was about 600 cu. ft. per minute and the mixer was a ½-cu. yd. size. It was charged from overhead bins by hand, operated by sliding

TABLE V.—TIME-STUDY NO. 1.

Consec. No. of shot.	Charging mixer, sec	Closing door, sec.	Discharging mixer, sec.	Wait for rise in air pressure, sec.
1	10	4	13	23
2	10	2	13	11
3	9	3	17	15
4	8	5	14	16
5	10	5	17	20
6	11	2	20	14
7	11	6	19	20
8	9	6	15	19
9	10	5	18	..
Average	9.8	4.2	16.2	17.2

Average time per shot, 47.4 seconds. Length of conveyor pipe line, 315 feet. Vertical rise of pipe, 15 feet. Bends in pipe, 270 degrees.

gates immediately over the measuring hopper; two laborers controlled the sand and stone gates and one laborer operated the gate to the measuring hopper and also the air valves, and another laborer operated the water valve and assisted the mixer operator, making five men at the mixer.

TABLE VI.—TIME-STUDY NO. 2.

Consec. No. of shot.	Charging mixer, sec.	Closing door, sec.	Discharging mixer, sec.
1	8	3	7
2	5	3	11
3	9	1	9
4	7	4	8
5	6	4	9
6	7	5	9
7	5	5	12
8	7	9	11
9	6	3	10
10	5	5	11
11	7	5	10
12	5	4	13
Average	8.7	4.4	10.0

Average time per shot, 23.1 seconds. Length of conveyor pipe, 102 feet. Vertical rise of pipe, 37 feet. Bends in pipe line, 205 degrees.

Note that a 600-ft. compressor was used and that the average time of waiting for the air pressure to come up was 17.2 seconds in time study No. 1, where the distance was 350 ft. In study No. 2 where the distance was only 102 ft. there was no wait for air pressure.

ANNUAL CONVENTION OF THE AMERICAN CONCRETE INSTITUTE.

The annual convention of the American Concrete Institute will be held in Chicago on Feb. 14 to 17 inclusive, in order that the members present may have an opportunity to attend the Cement Show and some of the meetings of other organizations which will convene in that city during the same week. The Institute's directors desire to co-operate as completely as possible with those other societies which are specializing in concrete work and for this reason the program has not been definitely settled. The sessions of the Institute will be held in the morning and evening, and it is expected that joint sessions with other organizations will be arranged for some of the afternoons. The annual banquet will be held on the evening of Feb. 16.

In addition to important committee reports, the following papers have been definitely promised: C. W. Simpson, The Construction of the New Concrete Viaducts on the Lackawanna Railroad; Earl B. Smith, Tests of Large Size Concrete Slabs; P. P. Furber, Requirements of Building Codes for Columns and the Design of Columns; W. P. Anderson, The Design of Reinforced Concrete Buildings; Frank Raschig, Concrete Viaducts; Maynard & Baker, Concrete on the Massachusetts State Farm; Ralph A. Sherwin, Forms for Concrete; Edward D. Boyer, Swimming Pools; Moore & Fuller, Tests Showing Continued Deformation under Constant Load; R. D. Stubbs, Pavements; H. S. Van Acoyoc, The Construction of the Toronto-Hamilton Highway by Day Labor; Chas. Upham, The Construction of the DuPont Concrete Boulevard; Wm. M. Acheson, The Essential Features for the Successful Construction of Concrete Highways; Clifford Richardson, Concrete Foundations for Heavy Traffic Street Pavements; Chas. C. Brown, How Shall a Rational Specification for Gravel Concrete be Developed; D. A. Abrams, Tests of Sands for Concrete; George A. Rankin, The Nature of Portland Cement; J. M. Braune, Tests of Concrete Materials at Cincinnati; W. K. Hatt, The Genesis of Reinforced Concrete Construction; Burtis S. Brown, Recent Tests of Reinforced Concrete Columns; W. W. Horner, The Design of Plain and Reinforced Concrete Sewers; Coleman Meriwether, The Manufacture and Use of Reinforced Concrete Pipe; J. H. Libberton, The Durability of Concrete Pipe; George Sampson, The Reinforced Concrete Water Tower at Middleboro, Mass.; Lamar Lyndon, The Design and Construction of the New Dam and Reservoir at Austin, Tex.; Wilson Fitch Smith, Methods of Construction at the Kensico Dam, Catskill Water Supply, New York City; Frank H. Fay, Concrete Conduits at Fall River, Mass.; Ridgway & Goodwin, Novel Methods of Concrete Construction on the New Subways in New York; Wm. C. Archer, The Operation of the New York Workman's Compensation Law to Date; H. L. Lowman, An Interpretation of the New Standard Building Contract Documents.

In addition to those papers definitely promised, a large number have been conditionally promised.

A SET OF TEN SIMPLE DIRECTIONS FOR SMALL USERS OF CONCRETE.

The following directions for making concrete mixtures that are reliable are prepared by the Association of American Portland Cement Manufacturers for the instruction of occasional users of concrete in small work:

Aggregates to Be Used in Concrete Construction.—The sand, stone, and gravel usually found upon the farms of the United States are generally suitable for concrete construction, provided the following precautions are taken:

(1) These aggregates must be free from vegetable matter, dirt, or other foreign substances.

(2) When using bank-run gravel, the sand must be separated from the stone or pebbles by screening through a ¼-in. screen.

(3) In small concrete structures, such as drain tile, fence posts, etc., the coarse aggregate (crushed rock or gravel) should range in size from ½ in. to ¼ in. For larger work, such as silos, barn floors, ordinary foundations, etc., coarse aggregate should range from 1½ in. to ¼ in.

(4) The sand used should be coarse, hard, and clean, and graded from ¼ in. to fine, with the larger size predominating. Use great care in hand mixing. It is economical to buy a small machine mixer if the farmer intends to use concrete in large quantities.

Hand Mixing.—Proper methods when concrete is mixed by hand, using a two-bag batch of 1:2:4 proportions, are as follows:

(1) Size of measuring box for sand should be 2 ft. square by 1 ft. high, thus containing 4 cu. ft.

(2) Load sand in wheelbarrows and wheel onto mixing board.

(3) Fill sand-measuring box, lift box, and spread sand 4 in. thick over board.

(4) Take two bags of cement, place contents as evenly as possible over sand.

(5) Turn the sand and cement over until thoroughly mixed, so that no streaks of cement or sand appear.

(6) Spread the mixture of sand and cement out carefully, place measuring box beside it, and fill twice with stone or gravel, then empty onto sand and cement mixture and mix thoroughly.

(7) Add three-quarters of required amount of water slowly and evenly, at same time mixing the mass.

(8) Continue mixing, adding balance of water when dry spots appear, until whole mass has been turned over three or four times. This should be sufficient. After final turning shovel into compact mass ready for wheeling to place.

MINIMUM SLOPES FOR CONCRETE CHUTES.

To the Editors: I have read with much interest the letter from your correspondent on the subject of the minimum slope for concrete chutes in your issue of Dec. 8, 1915. The high character of the work of your correspondent in the profession of engineering entitles him to speak with authority on any engineering subject. Certainly we must all agree that if the grading of the slope of a concrete chute is going to insure better concrete, then that slope must be determined upon and maintained, which will produce this absolute essential, good concrete.

But will any particular established minimum slope for the chute, as a factor in itself, have a value in regulating the quality of the concrete? To insure a good piece of work it is going to be necessary for the engineer in charge or for the contractor himself to constantly inspect the concrete before it reaches the chutes and to see that it is properly assembled and of the right consistency and if it is so inspected the slope of the chute can well be allowed to take care of itself so far as the resultant concrete in place is concerned.

I have found that for work in a gravity plant, the concrete as it stands in the hoisting bucket should not pile up, neither should it have water standing on top. The first indicates a mixture drier than is necessary and the second one, which is too wet.

This mixture holds all of the aggregates in suspension in the hoisting bucket and throughout the travel through the chutes to the forms and will produce a perfect piece of finished concrete. Concrete mixed with all of the aggregates in suspension will flow readily on a slope of 1 to 3; that is, about 18 degrees. There is so much work of great importance, both public and private, throughout the country, the concrete in which has been mixed and placed as indicated and which concrete is of the highest quality, that this mixture and slope cannot be questioned as producing the very best results.

We will all agree that concrete mixed with a consistency such that it will flow readily on a slope of 30 degrees, a grade of about 1 to 1¾, but requiring this slope to carry it, will undoubtedly produce excellent results, but to maintain these good results requires as close a supervision of the assembly of the concrete as is required to insure the more plastic mixture which still holds all of the aggregates in suspension and which will flow readily, under average conditions, at a grade of about 18 degrees and will produce as perfect a piece of work as it is possible to produce by any method.

The careless contractor is always with us and shows his aptitude in producing poor work, whether he takes up a cart or bucket or a spouting plant, and good work with any equipment is gotten only by constant care on the part of those ultimately responsible for results. Because this careless contractor has done poor work with the gravity plant, should the rest of the contractors throughout the country be penalized by the requirement that they add practically 100 per cent to the cost of the plant for towers and tower equipment? The inexperienced contractor will produce poorer concrete with the more rapid velocities obtained in a chute at 30 degrees than with one at 17 degrees and this increase in grade means for the experienced contractor only an increase in plant cost with no compensating value in the quality of the work produced.

Respectfully submitted,
W. H. INSLEY.

Indianapolis, Ind
Dec. 17, 1915.

BRIDGES

DETAILS OF TRAVELERS AND JACKS USED IN ERECTION OF HELL GATE ARCH SPAN.

The travelers and the jacks used in erecting the Hell Gate arch are interesting pieces of equipment, as their special features and large capacities contributed largely to the success attending the erection of this exceptional span. The following data give essential details of each:

Arch and Backstay Travelers.—Each arch traveler had a 65-ft. boom and was designed to lift a load of 175 tons at a radius of from 30 to 54 ft. The rigging was very heavy and the main fall lines were especially interesting. The latter consisted of a ⅞-in. plow steel cable, 7,000 ft. long, rove in 26 parts on two 13-sheave blocks. It was rove over the sheaves directly from one side to the other, and the ends of the cable were attached to separate hoists. The running lines were therefore at the outside of the blocks, and the center lines were standing if the two-lead line spuds were the same. The greatest lift of about 185 tons, the first bottom chord members, was the lowest, while the highest lifts near the center of the span were much lighter, and in order to increase the efficiency of the tackle a very ingenious scheme was used. The lower block was made in five sections, the middle three of which were removable. By taking one or three of these sections from the lower block, and bolting it to the bottom of the block, the number of parts in the fall line could be changed from 26 to 20 or 12, without reeving.

The boom of the traveler used for erecting the backstays of the arch span was 112 ft. long and was rigged with a 12-part, ¾-in. fall line, 4,800 ft. long. The boom falls consisted of a 26-part, ¾-in. cable, 3,000 ft. long. This traveler was designed to lift about 62 tons at a 50-ft. radius or 40 tons at a 96-ft. radius.

Jacks.—The four jacks used at the towers of the arch span have a capacity of 2,500 tons each, and, even though they are the largest of their kind ever used, they are extremely simple and by no means mark the limit of size. Each jack consists of only three parts: a cast steel cylinder, a top ring, and a cast iron plunger. The walls of the cylinder are 6½ in. thick, and the plunger, which is cored to a minimum thickness of wall of 6 in., is 3 ft. 3 in. in diameter. The sides and bottom of the plunger are plain except for a small lug on the bottom, which allows the water to get under it. The bore of the cylinder is 3 ft. 3 1/64 in. except for the lower 3 in., where it is slightly larger. The packing consists of six 1-in. square rings of hemp set into the cylinder walls near the top and held down by a ring bolted down with 28 1¾-in. stud bolts. The inside of the cylinder is 34 in. high, and the base is 9 in. thick. It is tapped at the bottom for a ¾-in. double standard pipe.

The pump was operated with a Blake-Knowles air-driven pump, equipped with an 8-in. air cylinder, a 1-in. water cylinder, and a 12-in. stroke.

The system was designed for a hydraulic pressure of 4,000 lb. per square inch, but it was tested to 7,000 lb. per square inch. The two jacks on each tower were operated by the same pump, shut off valves being used to regulate their respective movements. The jacks were lowered by bleeding through a bronze-and-steel needle valve having a ⅛-in. orifice. The fact that 2,500 tons could be lifted with such a simple apparatus, with no greater physical exertion than the opening of a valve, is a striking example of what can be accomplished by intelligent planning and designing.—From article by C. S. Whitney in The Cornell Civil Engineer.

DESIGN OF THE MASSACHUSETTS STREET BRIDGE OVER THE KANSAS RIVER AT LAWRENCE, KANSAS.

(Staff Article.)

The reinforced concrete arch bridge now under construction over the Kansas River at Massachusetts St., Lawrence, Kans., is an interesting example of a long-span arch structure involving difficult foundation work. The bridge has a total length of 1,026 ft. 3 in., and consists of two 29-ft. concrete girder spans, one 48-ft. 4-in. steel girder span encased in concrete, and six 132-ft. concrete arch spans. The girder spans, which are at the south end of the structure, were designed to furnish a crossing over three tracks of the Santa Fe. The piers and the main abutment for the south half of the bridge are carried to solid limestone, which lies at a depth of only a few feet below the bed of the river. Near the middle of the bridge, however, the limestone bed ends abruptly and the piers and abutment for the north half of the structure are carried down to a stratum of blue sandy shale, which lies at a depth of from 35 to 40 ft. below the bed of the river. The bents which support the girder spans have spread footings resting on shale, while the abutment at this end of the bridge is founded on concrete piles. The bridge will provide a 30-ft. clear roadway and two 5-ft. sidewalks. There will be one electric railway track in the center of the roadway. The arch spans are on a grade of 1.5 per cent, while the girder spans over the roadway and railroad tracks are level. Figure 1 is a general elevation of the bridge. This drawing gives the general dimensions of the structure and indicates the subsoil conditions. The bridge will replace an old structure consisting of six steel spans on masonry piers and abutments.

Loads, Allowable Stresses and Concrete Proportions.

Dead Load.—In determining the dead load the weights of the various materials were taken as follows: Concrete, 150 lb. per cubic foot; brick paving, including sand cushion, 60 lb. per square foot; sand fill, 120 lb. per cubic foot; ballast, 120 lb. per cubic foot; rails and ties, 134 lb. per linear foot of track; and materials in conduit spaces, 250 lb. per linear foot of span.

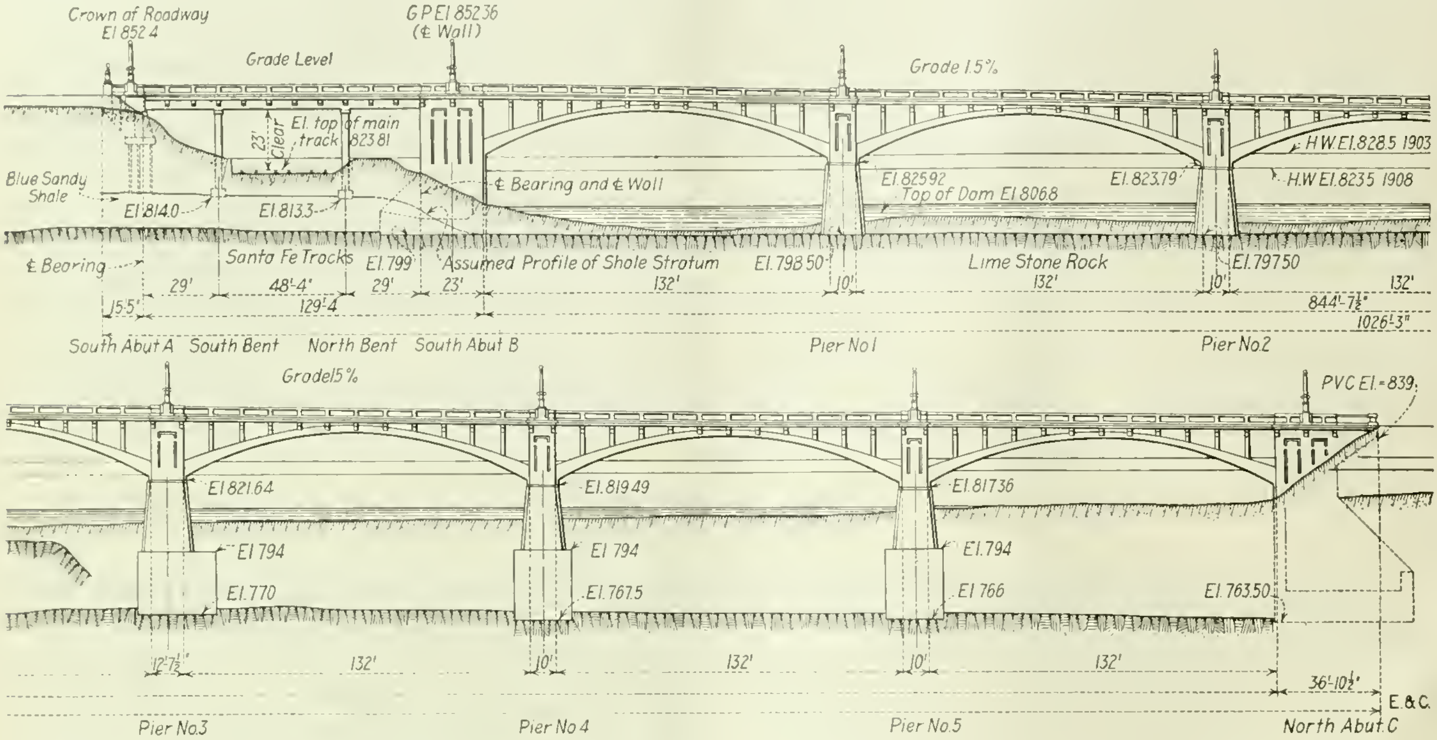
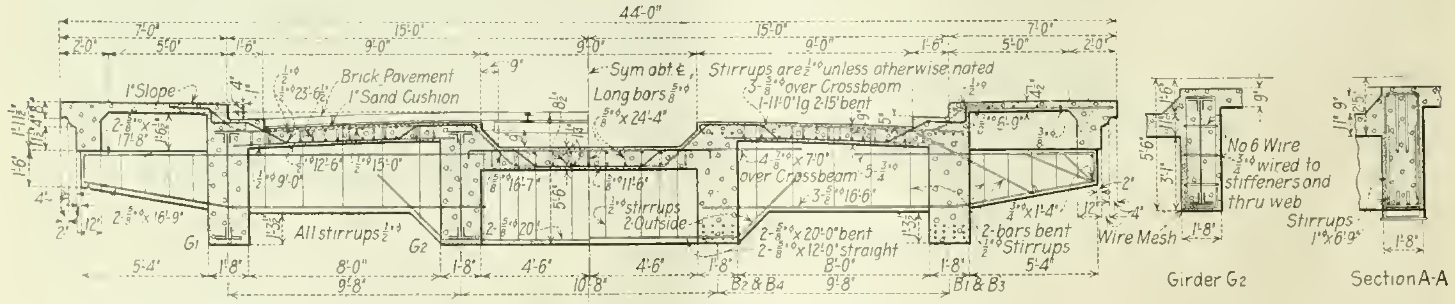
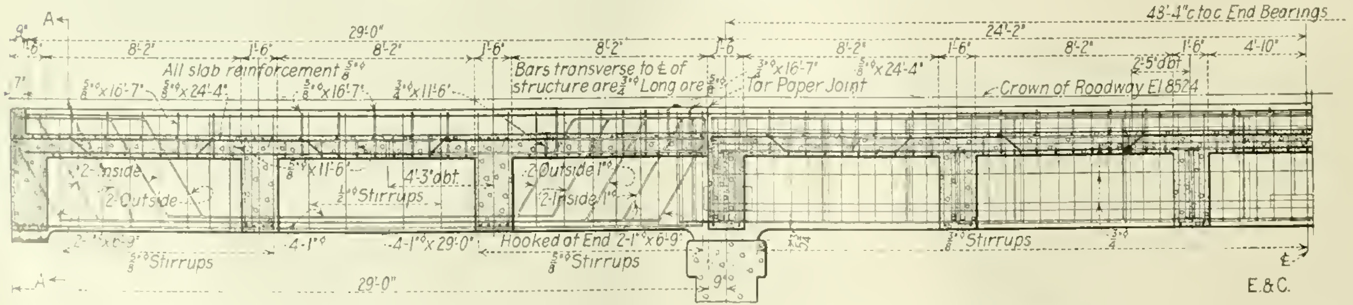


Fig. 1—General Elevation of Reinforced Concrete Bridge Over Kansas River at Lawrence, Kans.

Live Loads.—For roadway floor slabs, fascia girders, beams, cross girders, spandrel columns and approach girder spans the assumed live load over the portion covered by the track (assumed to be 12 ft. in width) consisted of a continuous line of 75-ton cars, or two axle loads of 45,000 lb. each, spaced 6 ft. on centers. The live load over the remainder of the roadway consisted of a 20-ton road roller, or a uniform load of 200 lb. per square foot. The live load over the sidewalks was taken at 150 lb. per square foot.



(a) Half Cross Section Steel Girder (b) Half Cross Section Concrete Girder Girder G2 Section A-A



(c) Concrete Beam B2 (d) Encased Steel Girder

Fig. 2—Details of Girder Spans Over Santa Fe Tracks of Bridge Across Kansas River at Lawrence, Kans.—Center Span Consists of Steel Girders Encased in Concrete; Side Spans Are Reinforced Concrete Girders.

For the arch rings and abutments the live load over the 12-ft. width of track consisted of a continuous line of 75-ton cars; that over the remainder of the roadway consisted of a uniform load of 60 lb. per square foot; and that over the sidewalks 50 lb. per square foot: or an equivalent live load per linear foot of arch ring varying from 8,520 lb. for a loaded length of 15 ft. to 5,060 lb. for a loaded length of 140 ft. or over. The latter loading was used only for the preliminary calculations; influence lines and actual concentrations were used in the final design.

For the unbalanced load on the piers, the loading over the 12-ft. width of track was taken at 3,500 lb. per linear foot of span; that over the remainder of the roadway was taken at 50 lb. per square foot; and that over the sidewalks 40 lb. per square foot.

Allowable Stresses.—For the floor slabs, rectangular beams, and T-beams the allowable unit stresses were: Concrete in compression, 600 lb.; reinforcing steel in tension, 16,000 lb.; and shear in concrete reinforced, 120 lb.

For the reinforced concrete columns the compression on concrete was taken at 350 lb. per square inch.

For the arch rings the compression on concrete, including live load, dead load, and rib shortening, was taken at 600 lb. per square inch; while the compression on concrete, including live load, dead load, rib shortening and a temperature variation of 40° F. each way from normal, was taken at 800 lb. per square inch.

In designing, the moduli of elasticity of concrete and steel were taken at 2,000,000 and 30,000,000 lb., respectively, and the coefficient of expansion was taken at 0.0000055.

Concrete Proportions.—For the entire abutment A (see Fig. 1) except that portion above a plane 1 ft. 6½ in. below the crown of the roadway, for abutments B and C below a plane 9.5 ft. below the springing line of the arch rings, and for piers Nos. 1, 2, 3, 4 and 5 below the offset or shoulder 24 ft. 3 in. below the crown of the roadway the concrete proportions are 1 part cement, 3 parts sand, and 5 parts stone, broken to pass in any direction through a 2-in. ring and varying in size down to ¼-in. pieces.

For the arch rings, for the solid portions of the piers above a plane 24 ft. 3 in. below the crown of the roadway, for the solid portions of abutments B and C above a plane of 9.5 ft. below the springing line, and for the two bents between abutments A and B the concrete proportions are 1 part cement, 2 parts sand, and 4 parts stone, broken to pass in any direction through a 1½-in. ring and varying in size down to ¼-in. pieces.

For all other parts of the structure except sidewalk slabs, curbs, gutters, railings, lamp posts, pedestals and monuments the concrete proportions are 1 part cement, 2 parts sand, and 4 parts stone, broken to pass in any direction through a 1-in. ring and varying in size down to ¼-in. pieces.

For the sidewalk slabs, curbs, gutters, railings, lamp posts, pedestals and monuments the concrete proportions are 1 part cement, 2 parts sand, and 4 parts stone, broken to pass in any direction through a ½-in. ring and varying down to ⅛-in. pieces.

Design of Superstructure.

Girder Spans.—As has been noted, there are three girder spans—a deck plate girder span 48 ft. 4 in. long, encased in concrete and located directly over the three railway tracks of the Santa Fe, and two 29-ft. reinforced concrete girder spans, one on each side of the plate girder span. Each span consists of four lines of girders, the inside girders being spaced 10 ft. 8 in. on centers, while the distance between an inside and an outside line of girders is 9 ft. 8 in. The 5-ft. sidewalks are cantilevered from the outside lines of girders, by means of brackets. The floor slab between the inside lines of girders is depressed below that on the remainder of the roadway, to provide space for the ballast and ties of the street railway track. The floorbeams of both the reinforced concrete and the steel spans are spaced 9 ft. 8 in. on centers, those for the steel spans being latticed steel members encased in concrete.

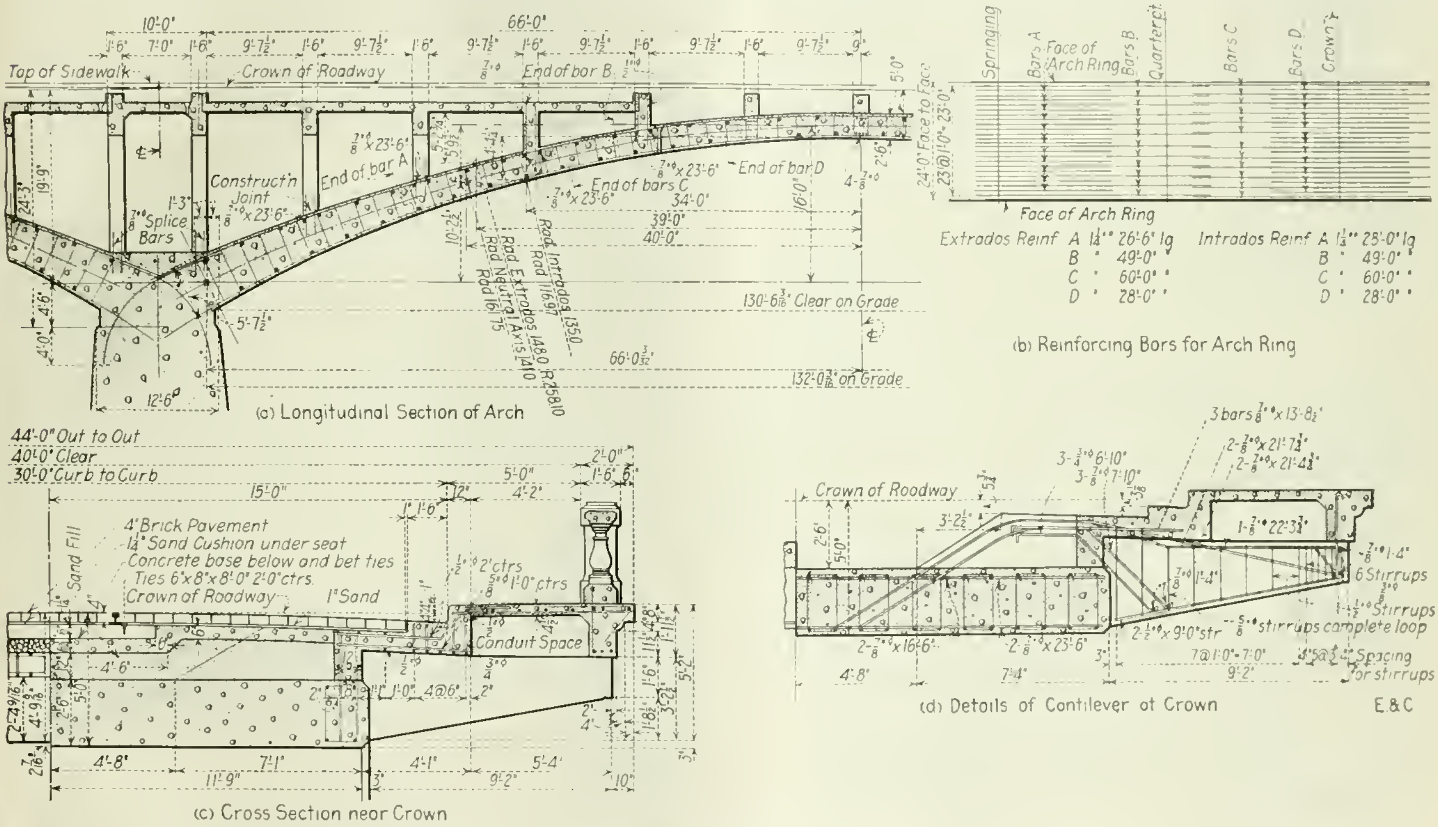
Figure 2 (a) is a half cross section of the steel girder span; Fig. 2 (b) is a half cross section of a reinforced concrete girder span; Fig. 2 (c) is a section through the floorbeams of a reinforced concrete girder span showing the longitudinal elevation of a girder; and Fig. 2 (d) is a section through the floorbeams of the steel span showing a half elevation of an encased steel girder.

The reinforced concrete sidewalk slabs have a thickness of 4½ in.; the roadway slab under the street railway tracks has a thickness of 11 in.; and the slab over the remainder of the roadway a thickness of 9 in. The dimensions of the various members and the reinforcing details are shown in Fig. 2.

Arch Spans.—The arch spans are six in number, each arch having a clear span of 132 ft. These spans are of the open spandrel type, with solid soffits. Each arch ring has a width of 24 ft., a thickness at the crown of 2 ft. 6 in., and a thickness at the springing line of 5 ft. 7½ in. The arches are three-centered, with a rise, measured at the neutral axis, of 16 ft.

The sidewalks and a portion of the roadway at each side are carried on cantilever brackets. The spaces between the tops of these brackets and the sidewalk slabs are used for water and gas mains and for conduits.

Each arch span is divided into twelve 11-ft. 1½-in. panels. The roadway deck consists of a reinforced concrete slab, except in the four center panels of each span; here the slab is omitted over the flat arch ring and a sand fill is provided to support the pavement. The spandrel walls at each panel point are 18 in. thick and are re-



(a) Longitudinal Section of Arch

(b) Reinforcing Bars for Arch Ring

(c) Cross Section near Crown

(d) Details of Cantilever at Crown

Fig. 3—Details of Arch Ring and Floor System of 132-ft. Arch Spans of Bridge Over Kansas River at Lawrence, Kans.

inforced with horizontal and vertical bars. These walls have three openings in them, each 4 ft. wide, the openings extending up to planes 4 ft. 9 9/16 in. below the crown of the finished roadway.

Figure 3 (a) is a half longitudinal section of an arch span showing the dimensions and reinforcement of the arch ring; Fig. 3 (b) is a plan showing the arrangement and size of the reinforcing bars in the arch ring; Fig. 3 (c) is a half cross section near the crown of the arch; and Fig. 3 (d) is a detail of the cantilever at the crown.

Expansion Joints.—There are 25 main expansion joints in the bridge, one at the south abutment A and four in each of the six arch spans; these joints are to be filled with asphaltic cement. In addition there are two expansion joints at the Santa Fe span, one over each bent, to prevent cracks due to continuity over the supports. Each joint is provided with lead plates built into the concrete for the full width of the bridge.

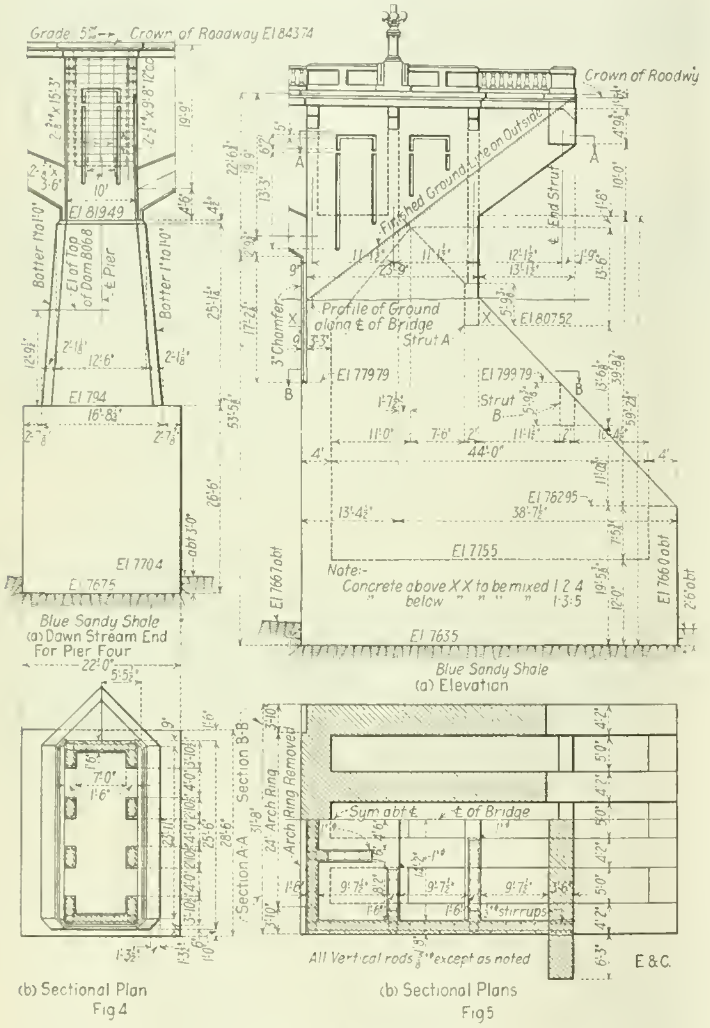


Fig. 4—Details of Pier No. 4 of Bridge Over Kansas River at Lawrence, Kans.—For Location of Pier See Fig. 1. Fig. 5—Details of North Abutment of Bridge Over Kansas River at Lawrence, Kans.

Waterproofing and Drainage.—There are 28 cast iron scuppers embedded in the curbs, two in each 29-ft. girder span and four in each arch span.

The 9-ft. trough for the street railway track is to be waterproofed with a 1-in. layer of asphaltic mastic laid in two courses. In all four sides of each section formed by the expansion joints a 4 x 1/16-in. strip of sheet lead, embedded to a depth of 2 in., is provided to form a flashing for the mastic. The mastic is to be composed of asphaltic cement mixed with sand, or sand and fine gravel, enough cement being used to fill all voids. Before mixing the cement and sand each is to be heated to a temperature of about 350 F.

Design of Bents for Girder Spans.

The 44-ft. 8-in. girder span and the adjacent ends of the 29-ft. spans at the south end of the bridge are supported on three-column, reinforced concrete bents having spread footings resting on shale. The south bent has a total height of 32 ft. 5 in. and the north one a total height of 33 ft. 2 in. The outside columns are 30 x 36 in. in section, while the interior ones are 30 x 42 in. The three columns in each bent are spaced 15 ft. on centers, while the four longitudinal girders are spaced 9 ft. 8 in. on centers. The top girder of these bents has a depth of 5 ft.

Design of Piers and Abutments.

Piers.—As noted in Fig. 1, the two piers in the south half of the bridge are founded on solid limestone, which lies a few feet below the bed of the river; while the three piers in the north half have pneumatic caisson foundations founded on blue sandy shale, these caissons extending to a depth of between 35 and 40 ft. below the river bed. It will be noted that pier No. 3 is designed to take the unbalanced thrust due to the arch ring on the south side of the pier, to enable the centers for the south three arch rings to be struck before the north three are built. The pier shafts have angular cutwaters with steel nosings on the upstream side. Each pier is surmounted with two ornamental pedestals, each carrying an ornamental combined lamp and wire pole.

With the exception of the bases of those piers having caisson foundations, all piers are of the same type. Figure 4 (a) is an east (downstream) elevation of pier No. 4 and Fig. 4 (c) is a sectional plan of it.

As it is planned to erect the three south arch spans first, the shaft of pier No. 3 is increased in size and its base extended to the north, as shown in Fig. 1.

The shafts of piers Nos. 1 and 2 are founded directly on the solid limestone, no bases being used. The principal dimensions of these piers are given in Fig. 1.

Abutments.—Abutment A, which is located at the south end of the girder spans, is founded on concrete piles driven to shale; abutment B, which is at the south end of the arch spans, is carried down to solid rock; and abutment C, which is located at the north end of the bridge, is carried down to shale by the pneumatic process (see Fig. 1). The depths to which the footings of these abutments extend below the crown of the roadway are as follows: Pier A, 18 ft. 4¾ in.; pier B, about 53 ft.; and pier C, about 76 ft.

Figure 5 (a) is a side elevation of abutment C, and Fig. 5 (b) are sectional plans of it. The longitudinal abutment walls and the main parts of the abutment are heavily reinforced.

A somewhat similar design was used for abutment B, this abutment also consisting of four main longitudinal walls heavily reinforced in their upper parts and braced together.

Abutment A is of the gravity type, with short, irregular-shaped wing-walls. It is supported on 33 concrete piles.

Quantities of Materials.

The following are the quantities of the principal items in connection with the construction of this bridge:

Concrete in piers Nos. 1 and 2 below elev. 806.8 (top of dam), cu. yd.	307
Concrete in piers Nos. 1 and 2 between elev. 806.8 and a plane 24 ft. 3 in. below crown of roadway (see Fig. 1), cu. yd.	539
Concrete in pneumatic bases of piers Nos. 3, 4 and 5 below elev. 794.0, cu. yd.	2,025
Concrete in shafts of piers Nos. 3, 4 and 5, between elev. 794.0 and a plane 24 ft. 3 in. below crown of roadway, cu. yd.	1,287
Concrete in abutment A below top of sidewalks, cu. yd.	220
Concrete piling in abutment (33 piles), lin. ft.	680
Concrete in abutment B below a plane 9.5 ft. below springing line of arch ring, cu. yd.	618
Concrete in abutment C below a plane 9.5 ft. below springing line of arch ring, cu. yd.	1,584
Concrete in north and south bents of Santa Fe crossing, cu. yd.	104
Concrete in arch rings; in solid portions of piers between arch rings and a plane 24 ft. 3 in. below crown of roadway; and in solid portions of abutments B and C above a plane 9.5 below springing line, cu. yd.	3,231
Concrete in arch spans above arch rings and below top of sidewalks (except paving base and fill); in piers above solid portions between arch rings and top of sidewalks; and in abutments B and C above solid portions thereof and below top of sidewalks, cu. yd.	2,144
Concrete in three girder spans between abutment A and B above bents and below top of sidewalks, cu. yd.	315
Concrete in 16 lamp post pedestals, in 2 pedestals at abutment C, and in 2 monuments at south end, cu. yd.	83
Railings and railing posts between pedestals, lin. ft.	1,814
Reinforcing bars, ¾-in. and over, lb.	400,000
Reinforcing bars, under ¾-in., lb.	200,000
Structural steel and castings in span over Santa Fe tracks, lb.	78,500
Steel angles and bolts in cutwater, lb.	4,500
Curb angles, lb.	3,700
Lead plates, lb.	7,500
Sand fill on arch spans, cu. yd.	340
Earth excavation for piers Nos. 1 and 2, from mud line to bed rock, cu. yd.	200

Earth excavation for piers Nos. 3, 4 and 5 and abutment C, from mud or ground line to shale, cu. yd.	5,750
Earth excavation for abutments A and B and for bents at Santa Fe crossing, cu. yd.	1,120
Excavation in limestone, cu. yd.	220
Excavation in blue sand shale for piers Nos. 3, 4 and 5 and abutment C, cu. yd.	400
All other excavation in blue sandy shale, cu. yd.	300
Waterproofing under tracks, sq. ft.	7,000
Asphaltic cement in expansion joints, gallons	340
Approach fills, cu. yd.	17,500

The above quantities do not include materials in pavement, track, ballast or lighting system.

Personnel.—The bridge was designed by Hedrick & Cochrane, consulting engineers, Kansas City, Mo. It is being built for Douglas County, Kansas; Gus H. Brum, chairman, Board of Commissioners, Lloyd Duffee, county engineer.

EFFICIENCY IN THE RAILWAY BRIDGE AND BUILDING DEPARTMENT.*

By George W. Rear, General Bridge Inspector, Southern Pacific Ry.

The work of the bridge and building department is of such great variety that it covers almost all of the building trades and some of the mechanical trades as well. As the work is scattered over a large territory it is hardly to be expected that as great efficiency can be secured as where the work is concentrated.

Men Available and Working Conditions.—Before going into the conditions of labor, let us look at the personnel of the department, beginning with the men in the ranks. The mature man one hires usually has some drawback. He is a wanderer, or a chronic kicker, or has one or more of the many faults human nature is heir to. He often expends more energy hunting a job than he does in doing it after he secures it. He has probably made up his mind that a railroad job is a snap and tries to make it one. When men are scarce and work must be done these men must be tolerated, but at a great loss of efficiency in the work.

The only alternative is to keep the good men that we have and hire young men and train them ourselves. This is the foundation on which we must build the department.

Why do men leave us? Assuming that we have trained the man, what do we lose when we lose his services? Perhaps the railroad does not lose much in dollars and cents, as he has probably earned all he received while being trained, but it has lost a very material part of the organization and the benefit of his service in the years to come.

One reason his training has not cost much is because no special pains have been taken to train him. He begins as a laborer, works a year or two and becomes a handy-man, then secures a few tools and becomes a mechanic. Is he encouraged to advance? Probably not. If he is energetic, smart or likely to become a valuable man is he dropped or "hidden under a bushel" for fear he will displace some older man? Is he kept away from home for weeks at a time and considered a nuisance if he asks for transportation home often enough to keep up an acquaintance with his family or associates? Are his wages anywhere near what they ought to be? Are his living conditions good or even fair? Is he laid off whenever work is slack? In other words, is his job worth having? These are questions that must be looked squarely in the face. They have little or nothing to do with what work a man will accomplish, but they are of vital importance in determining whether or not we have any men at all.

Thousands of young men of fair education are looking for a start on a life career every year. Are we getting our share of them? Have we anything to offer them? On the answers to these questions depends the future efficiency of the Bridge and Building Department.

It is efficient now, probably more so than other departments, but it is largely so in spite of conditions, except where proper methods are in force. Conditions are nowhere ideal, but much has been done, mainly by individual effort.

How to Attract Good Men.—If we are to get and keep good men we must hire young men of good health, good habits and fair education; we must put them at unskilled work (if there is such a thing) and give them a chance to learn the work, for it is a trade or profession of its own; we must also pay them proper wages. What constitute proper wages is open to discussion, but it does not help the department to have boys leave the farm and get more pay as brakemen to begin with than bridge and building men ever hope to get.

We must make their living conditions agreeable. If required to be away from home they should have good living accommodations. Some of these men spend half their lives in an outfit car. Don't crowd too many men in a car, but provide some privacy and arrange so that men who are congenial can be grouped together. We must not forget to feed them properly. Quantity and variety of provisions are not the only things to consider, for the way that they are served is an important item.

Let the men go home often. The man who sticks closest to civilization is the best citizen and the most valuable man. If circumstances permit let him go home every night; don't keep him away for fear that the boarding camp will lose money or to save some clerk the trouble of writing passes. Consider transportation as a man's right and do not try to make him think that he is getting it as a favor. Treat the man as a human being and as an equal in everything except responsibility and authority, and make his job as secure as that of any other employee. He will be proud of his job and it will be easy to keep him.

Do not drive too close a bargain with him and do not expect to get more than you pay for. Men should be hired with as great care as those for any other department. A fair education should be insisted upon and a physical examination given. This examination should be governed somewhat by the trade he is to follow, without blindly turning down all applicants who are not perfect, but it should be strict enough to cull out all those not physically fit to do a day's work.

These employees should be considered as employees of the railroad and not of a gang. They should be transferred frequently from gang to gang and given an opportunity to learn the standards of work and the methods used by different foremen. The man himself should show a desire to become a real railroad employee, to learn the business, and to put up with its inconveniences without "growling."

If the men in the gang are not congenial and willing to work together as a team an effort should be made to locate the reason and change the men around or discharge those who are not willing to pull with the rest. When there is friction in a gang there is always some cause, and this should be located and removed.

It is not to be expected that any method of handling men will eliminate all dissatisfaction, for the millennium is not yet at hand, and while human nature is what it is there will be men who look on every action of their superiors with suspicion. However, if the gang is treated in the spirit of fair play the majority of the men will play fair.

The Foreman—Requirements and Duties.—The gang must be made to pull together, for co-operation is the real reason for working men in gangs. The older men should be given charge of the apprentices, and if the gang is large enough it should be divided into groups of five or six men each, each group in charge of one of the older men, who, in addition to being a good workman, has shown some of the qualities of leadership.

The foreman looks to these leaders to keep their fellow workers properly employed while they themselves are in training for positions as foremen, and they should be given an opportunity to familiarize themselves with the bookkeeping required of foremen. It is not to be expected that all of these men will make good foremen, but enough of them will have the proper qualities to provide a plentiful supply, and it will not be necessary to go outside of the employees to secure them.

In picking men for foremen those should be selected who are fair-minded, patient and good judges of human nature, in order that they may treat their men properly and secure their respect and confidence. A foreman should have the courage of his convictions; he should be energetic, resourceful, and have sufficient red-blood to be a leader. At the same time he should be quiet, firm and cool-headed so that neither he nor his men will "blow up" in an emergency. The loud-mouthed, profane driver may be necessary with mules and oxen, but he is out of place with intelligent human beings.

---

*Paper presented at the annual convention of the American Railway Bridge and Building Association in Detroit.

A foreman should be honest, loyal, painstaking, reliable, sober and willing, so that he may be a fit representative of the company that employs him and thus command the confidence of his superiors. He should be studious and observing, that he may advance in his profession and become capable of added responsibilty.

In considering the handling of men it may be well to remember a few established principles. There is a limit to the amount of work that can be got out of a man. The value of a man does not lie in his physical force, but in his mental capacity or ability to co-operate with other men, using his head as well as his hands. The system of handling men and work should be such that it would not depend on any individual to carry it out. There is no use in keeping a man who is not satisfied with the job and whose work is not congenial.

Foremen should be developed along definite lines, and where the system is in proper effect this will be accomplished by making the future foremen understudy the regular foremen. It is also advisable to have the future foremen placed directly under the eye of the supervisor for a time, so that he may be advised and instructed in details that otherwise might be overlooked.

In educating men for foremen, the following points should be given consideration:

The man should realize that he cannot do all of the work himself, and that it would be useless to try, neither should he think that because he is foreman he should not do any manual labor. The amount of manual labor that a foreman should do has always been a matter of argument, but common sense will show that this depends on the number of men in the gang and the class of work that is being done. The foreman in the gang is employed to see that each man in the gang does his share of the work and the nearer this result is attained the more efficient is the gang.

It is neither possible nor desirable that a foreman be given strict rules and instructions for every class of work, because this results in making him a mere machine. A foreman should be given enough leeway so that he will not lose his enthusiasm, but will feel that the work depends on him and not on the fact that he is carrying out another's ideas and instructions.

The successful foreman is one who keeps harmony among the men. His men work "for him" and not "because of him." A good foreman does not have to stand over his men and drive them with threats, neither does he have to discharge a man occasionally to make the others fear him. No man has ever accomplished much through fear.

A foreman should arrange the work so that there will be competition among the men. Have groups of men at the same kind of work so there will be a speed contest. This contest may only be subconscious, the men hardly realizing that there is a contest or rivalry, but it will result in an increased amount of work. It must be remembered, though, that it is the steady, regular work that counts, and that spectacular bursts of speed usually "fizzle" before long. These "high-speed plays" are all right if the work is of an emergency character and will be over in a few hours, but as a steady thing they are out of place. A man may be ambitious enough in the morning, but a few hours' steady work with a "number two" will serve to subdue his energy. It is the man who can select a gait at which he can keep all day who accomplishes the most.

Kind of Tools and Their Use.—A foreman should realize that he is not being paid for muscle or a strong back, but for his head and what there is in it, and he should employ every opportunity to use his head to save hard work. Human energy uselessly expended cannot be replaced and it should be conserved where possible or economical. To conserve and make human energy effective, tools have been developed. Without tools little can be accomplished, so it is a waste of labor to try to work without them.

These tools are two general kinds, hand and mechanical. The hand tools may not be exactly labor-saving, but their use makes labor effective and they should be of the best class obtainable. Keeping them in proper shape is a great aid to efficiency.

Mechanical tools are labor-saving devices, permitting the employment of steam or other power for work which would otherwise have to be done by men.

The locomotive crane is too expensive a tool for the ordinary bridge gang, but there should be enough of them on each supervisor's district to provide this equipment where needed. The modern car piledriver is a very efficient machine and each railroad should have enough of them to do their ordinary work and take care of emergencies. These drivers should be placed in the hands of efficient men and worked to as nearly full capacity as possible, as it does not pay to have them idle. With suitable attachments they can be used as light car derricks, and their sphere of usefulness thus enlarged.

Almost every bridge gang can find efficient uses for a hoisting engine and their use should be encouraged. The gasoline engine has been developed to such an extent that it is very reliable. The present-day workmen are so well acquainted with them, that there is no difficulty in finding someone to run them. They are very satisfactory for operating pumps, concrete mixers, etc.

Probably the greatest labor-saving device of the present day is the concrete mixer. An average bridge gang, doing ordinary work, will have considerable concrete to mix, and to do it by hand, especially with men not used to it, is a back-breaking job. It is impossible to keep good mechanics if they are put at this kind of work very often. The small mixer taking a one-bag batch is the best for an average bridge gang. It should be self-contained and require no great amount of time to set it up. A mixer mounted on wheels or skids with a gasoline engine directly connected to it is best. It is almost criminal to mix concrete by hand when power is available.

Pneumatic riveting and boring tools are not used by the average bridge gang, but every gang doing work on steel bridges must use these tools to do good work. They are not only economical, but rivets driven by pneumatic hammers are better than those driven by hand, and greater dependence can be placed on them. The motor car also adds greatly to the efficiency of a bridge gang, as the men can be taken to their work in less time and are in better physical condition when they get there. A bridge gang should be supplied with good jacks of proper size. The modern, ball-bearing screw jack is probably the best all-around jack, but each gang should also have some ratchet jacks for such work as they are suitable.

Furnishing the tools is the duty of the superior officers, but their up-keep depends on the foreman. With proper tools and men a gang is ready to go to work, and its efficiency depends on how the men go at it. Where a gang is employed on one kind of work it is easy to get the job under way, but where the work varies in character it is usually hard to get it started so as to keep all hands profitably employed. This is where a competent foreman can make a good showing, and on the amount of headwork he uses will depend the efficiency with which he starts his work.

A foreman will soon realize that although all men are born free and equal they do not remain so. Although all of his men may be good, some of them may be better than others. Neither are all men equal in the variety of work they can accomplish. Having men of different characters and propensities, it is the foreman's duty to see that, as far as possible, each man is put at the work most suited to him, and on his ability to do so his efficiency will greatly depend.

A foreman should be careful to avoid doing one of his men an injustice. It is not enough to be just. Some things are better forgotten or overlooked.

The Supervisor.—The department must have a head, and on this officer depends the efficiency of the division. To fill this position properly a man must have special training and experience. He must be familiar with all the building trades, must keep up to date in the use of tools and labor-saving devices, and must be an expert in the art of handling men. He must have all of the qualifications required of a foreman and in addition he should have the necessary qualifications to enter the diplomatic service.

His success depends on the regard in which his subordinates hold him, much more than that of his superiors. In handling men the most successful supervisor is the one who knows each man under him well enough to call him by his given name. He should see that his foremen understand his desires as to how the work is to be done, and, as few foremen are mindreaders, he should instruct them explicitly.

It is always best to let a foreman handle the details of the work in his own way, if his way is anywhere near right, but there should be a clear understanding in regard to it, so that the work may go on properly from the beginning. Once the work is outlined, proper material and tools should be provided and enough material for a good start should be on hand before the gang begins work. Much inefficiency is the result of not having material and tools when required. A supervisor should go over the plans with the foreman and see that they are understood. He should see that the foremen are provided with all equipment to protect the men from injury and see that it is used. Men do much more work if they have safe stagings, stairways, etc., and are relieved from anxiety while at work. It is useless to expect a man to swing a hammer over his head if he is afraid of falling off a plank. He must have good footing to do good work.

A system of cost accounts tends greatly to efficiency. Each foreman should be required to report the labor cost of each job done, and costs of similar work by the same or other foremen should be compared. It is not sufficient that these costs be taken from the auditor's accounts. They should be furnished by the foremen, as the fact that the foreman must work up the statement will cause him to be more careful in the handling of the work.

A supervisor should have gangs of proper size, properly equipped and located at the most convenient points, so that there may be no great loss of time in moving them around. These gangs should be organized to do all work of an ordinary character in their territories. Special gangs should be provided and specially equipped to handle the larger jobs of construction and reconstruction and such other special jobs that require special training and equipment.

Incentive for Work.—The greatest incentive for men to do a good day's work is to have plenty of work in front of them. It is almost impossible to do efficient work when the job is about finished and no other work in sight.

The most important of all points tending to efficiency is regularity of employment. It is useless to try to perfect an organization if it is to be broken up every winter or as soon as the earnings fall off temporarily. When it is arranged so that the work can be carried on continuously and employment made permanent then, and then only, will there be a real foundation on which to build an efficient organization.

Finally, we must not lose sight of the fact that the real business of a railroad is to provide transportation, and that all other work is only incidental thereto. We must not allow our efficient methods to interfere with the running of trains. We have no money to waste, but it is nearly always necessary to depart from the most economical methods to avoid delays to trains, consequently we must consider efficiency to mean—the most satisfactory method of conducting a railroad as a whole.

ROADS AND STREETS

PROPORTIONING OF CONCRETE FOR ROAD WORK; SUGGESTIONS FOR IMPROVEMENT AND OBSTACLES IN THE WAY.

Contributed by Major W. W. Crosby, Consulting Engineer, Baltimore, Maryland.

An editorial in Engineering and Contracting for Nov. 17, 1915, called attention to a new section in concrete road specifications, and an abstract of the important part of the specifications in this connection was printed on page 384 of the same issue. The editorial referred to was followed on the same page—381—by another editorial on "Chance," and the writer was struck with the peculiar applicability of the second editorial to the point of the first editorial.

What is the matter with engineering? Its followers complain that they are underpaid and unappreciated, and highway engineers particularly advance these complaints. Engineering is known to be one of the oldest sciences, but its professional development is said to have taken place since the construction of the Erie Canal, or within practically the last half century. Professionally therefore it may be regarded as relatively youthful and the complaints and claims may be taken as those of youth, even though the latter is particularly sturdy and capable.

Highway engineering is probably one of the youngest specialties, and it is not unnatural perhaps for its followers, though barely of age, to feel most keenly the lack of recognition accorded them and to be loudest in their cries and demands.

But instead of bewailing their condition, will not their interests be advanced most quickly by the application of the same amount of energy to the development of the scientific side of their specialty? At present the layman in most cases seems to think he knows as much about highway engineering as does the highway engineer himself, and often he is not far from right. The scientific principles underlying the art of highway construction are, so far as they have yet been established and developed by general agreement and experience, few and relatively simple, but as every highway engineer knows, who has attempted to see beyond the end of his nose, there are innumerable principles to be investigated and awaiting establishment. Thousands of every-day problems depend for their proper solution upon the establishment of these principles, but are being solved today in one way or another by guess work and by chance. As long as this condition shall continue, the layman has the right to believe that he is as competent as the average highway engineer; to fail or refuse to differentiate between one so-called highway engineer and another; and to believe that other things are equal and that the selection of a public official in the shape of a highway engineer may properly be decided from the political standpoint.

The remedy for these conditions, admittedly unsatisfactory to the real highway engineer, is the development of his profession so that the conditions mentioned shall not exist; that a real highway engineer shall know more of the scientific principles underlying his work than do other engineers or laymen, and shall thus have a preponderating claim for continuous employment at a satisfactory compensation.

Take the subject of concrete in illustration of the foregoing. Let us first review briefly the present situation.

Concrete foundations for pavements have generally been made 6 in. in thickness, and concrete pavements have, in the main, followed this practice. Just why, no one seems to be able to explain. It is simply an acknowledged custom. A few attempts have been made locally to break away from custom, but notwithstanding the success of these attempts, they are generally viewed with skepticism and commented on as radical and irrational. Just why it should be illogical for an engineer, who from the definition is supposed to get more for $1 than any other man can get, to endeavor to proportion the thickness of the layer of concrete supporting the loads to those loads, does not appear to the writer. On the other hand, he fully appreciates the responsibilities incurred by the engineer who departs from custom without special warrant of theory or experience for the departure, but he believes that sufficient development of a proper theory may often warrant a departure from practice for the sake of a test by experience, if for nothing more.

The proportioning of concrete is in somewhat the same situation. Before the use of Portland cement became common, the 1:2 mixture of Rosendale cement and sand had been generally adopted, largely because of the satisfactory consistency which such a mix gave to the mortar, and when the use of concrete began to increase, this 1:2 mortar plus four parts of the coarse aggregate was a natural result. When Portland cement was first introduced to common use about this time, its greater inherent strength was acknowledged, and its 1:4 mixture was at first considered equal to the 1:2 mixture with Rosendale cement. The 1:4 mixture with Portland cement, however, did not suit the masons using the mortar and a 1:3 mixture was found by them preferable, even 1:2 being used by them when practicable. Naturally also the 1:3:6 mixture for Portland cement concrete developed, and for many years now this latter mixture has been the one in general, if not in almost universal use for pavement foundations. Apparently it has been purely a matter of practice, and the proportions were reached without any consideration of the scientific facts involved.

With the advent of cement concrete pavements, it has become evident that the 1:3:6 mixture did not usually give as satisfactory results on the surface under traffic as was desirable and as appeared to be possible. Quite naturally, and certainly before any investigations had been made to determine the proper remedy, the first impulse in practice was to add more cement, and in this way a 1:2:4 mixture became fairly general in use. Apparently, the experience and developments with the use of bituminous mixtures, such as the sheet asphalt pavement and the so-called bitulithic pavement, were ignored by the cement concrete pavement people, although it seems to the writer that a sufficient similarity between these diffrent mixtures exists to have warranted consideration of the bituminous practice.

The 1:2:4 mixture for cement concrete roadways with slight variations proposed in some cases to meet certain local conditions or individual views, seem to have been pretty generally adopted as standard, but it should be evident that this standard is not an engineering standard, but rather a lay standard which has been developed by laymen, and is not one which has required any particular engineering ability for its establishment. The accomplishment of engineers in this particular may then be viewed by the public as questionable, and, as suggested, the public may be right in its attitude, to a certain extent at least, toward engineers.

Is it not a fact that experts in the matter of asphalt and bituminous pavements enjoy today a better position before the public than other engineers specializing in highway work, and is not this fact due to the scientific developments that have taken place along their lines in the past 10 or 15 years?

Recently some great strides have been made in the development of the scientific side of the use of concrete. S. E. Thompson, N. C. Johnson, J. A. Kitts, and others, have disclosed lodes of most valuable information which, by proper development, should yield facts of the greatest possible value in connection with all concrete work. Unless now engineers assist in the clarification or reduction of these facts and then make use of them in their practice, the writer believes that the profession will fail to do its duty and will then very properly remain in the place now complained of in the public estimation.

It was with a view to making use, for professional as well as general benefit, of the facts so far sufficiently established in the opinion of the writer, that he proposed the concrete specifications referred to in the editorial, and he is convinced that the time has arrived that this particular problem of the proper proportioning of concrete should be attacked for solution by engineers.

The obstacles in the way of the proposed solution; that is, the determination of the amount of cement and mortar to be used in proportion to the voids in the fine aggregate and the voids in the coarse aggregate, are:

First: The omnipresent opposition to anything new and the skepticism and opposition, temporarily at least, among laymen, some contractors, and, unfortunately, some engineers, to the advent of scientific methods in so-called "practical" work.

Second: Opposing custom.

Third: Physical difficulties.

As regards the first, space will not be used here for discussion further than to call attention to the fact that this obstacle is always to be expected and seldom, if ever, disappoints by not "bobbing up serenely" at every occasion. However, almost always, it has been overcome and may, and the writer thinks should, be overcome in this instance, by methods similar to those that have been successfully used to overcome it in the past.

As regards the second—custom—conventions—fashions—have engineers professionally the right to recognize anything short of standards, or to interfere with the establishment of standards by a too deep regard for one or more of the other three? Should not engineering as a profession profit by the exposition of "kultur" now before them, and, ignoring custom and leaving convention and fashion to their worshipers, which will never be wanting, apply themselves to developing rational standards for increased efficiency?

As regards the third—physical difficulties—it seems to some as though new methods proposed for proportioning the concrete would be impracticable because of the interference to the work required by the analyses of the materials. It is argued that the material for each batch would have to be analyzed previous to its use, but this seems an extreme view, as the cement certainly is not treated in this way. The cement nowadays is usually tested considerably in advance of its use and a sufficient supply of approved material kept on hand to avoid interference with its consumption. In the same way, why could not the fine and coarse aggregates be analyzed in advance and a reserve, sufficient to avoid interference in the use of each of them provided? As a matter of fact, this is what is done in the case of sheet asphalt mixtures and even with bituminous concrete mixtures, so that it would seem to be practicable with cement concrete mixtures.

It has been argued that lack of uniformity in the fine and coarse aggregates on hand would render impossible a sufficiently accurate determination of the voids in them by a few analyses and that for accuracy, the number of analyses required would render the method impracticable. The writer fails to see the real force of this argument in view of the satisfactory results secured in sheet asphalt mixtures by relatively few analyses of the fine aggregate, and he sees no great difficulties in obtaining equally satisfactory results in the case of the coarse aggregates along similar lines. Further, the proposition to allow an excess of cement of from 5 to 15 per cent more than the voids determined in the fine aggregate and an excess of mortar of from 5 to 15 per cent more than the voids determined in the coarse aggregate would certainly offset to a considerable degree minor lack of uniformity in these aggregates, and it would only be necessary to make such a number of analyses on both as would insure reasonable uniformity in the resulting mixture by providing compensation in the proportions for any extraordinary variation in the aggregates themselves. At any rate, it seems to the writer that non-uniformity in the mixture cannot be as great when the proportions are determined along these lines as when they are determined on an arbitrary basis of 1:2:4 or whatever figures are used. The value of uniformity in the resulting mixture needs no discussion here.

Perhaps the most practical obstacle in the way of the application of the principles and methods suggested is the fact that cement is usually now shipped in bags containing approximately 1 cu. ft. each, and convenience has accustomed the proportioning of the materials on the basis of the bag or possibly the ½ bag. Therefore it appears to some that the establishment of proportions which would require at any time the use of a fraction of a bag other than ½ is a practical obstacle to the successful application of the method. To the writer this argument does not appeal. Asphalt used to be shipped in barrels, but the proportioning of asphalt mixture was never based for any length of time on the barrel as a unit. Cement was shipped in barrels, then it was put up in bags, and is coming more or less to be shipped in bulk. There are serious objections to both the barrel and the bag, and it seems likely that ultimately their removal will be demanded and had, and that when this shall have occurred, it will be found that the objection now raised to the use of the unit other than the bag of cement as a basis for proportioning the mixture of the concrete will have disappeared.

Further, even if the bag or ½ bag of cement as a unit shall prevail for some time, will this fact be any real objection to the application of the method proposed? The figures of the excess—5 to 15 per cent—are empirical, and while they allow some leeway, it is readily possible to arrange them so as to allow somewhat more.

If the coarse aggregate shall show by analysis to have 31 per cent of voids and the fine aggregate to have 23 per cent of voids, then the mortar required will be, on the principle proposed, 8.37 cu. ft., and the cement required will be 1.93 cu. ft. or practically two bags of cement per cubic yard of concrete, if no allowance is made for any excess of mortar for voids in the coarse aggregate, nor for any excess of cement for voids in the fine aggregate. Now if any excess of cement (let us say 15 per cent), shall be allowed, then the amount of cement required will be 2.22 cu. ft. We then have the proportion of the various ingredients on the above basis as 1:3.77:12.16.

With the bag as unity for the cement, we can then measure the other ingredients in bags or fractions as thus determined, discrepancies in measuring the exact fraction of the bag required being less and less important as the proportion of particular material used in the mixture increased.

Eventually it may be found possible to go even further and to approach even more closely the procedure in bituminous concrete by proportioning the materials for cement concrete by weight, which would seem to the writer, as it does to some others, to be "an end devoutly to be wished," but in the meantime it would seem to him desirable that engineers generally should inaugurate proper principles for proportioning cement concrete.

ECONOMIC HIGHWAY CONSTRUCTION; AN ANALYSIS OF ROADWAY SECTIONS.

Contributed by F. W. Harris, Renton, Wash.

States and counties throughout the Union are issuing bonds, or increasing taxes to build new roads and improve the old ones. The taxpayer covers the entire area of the state so that the measure of success of the bond issue, is the number of miles of road built.

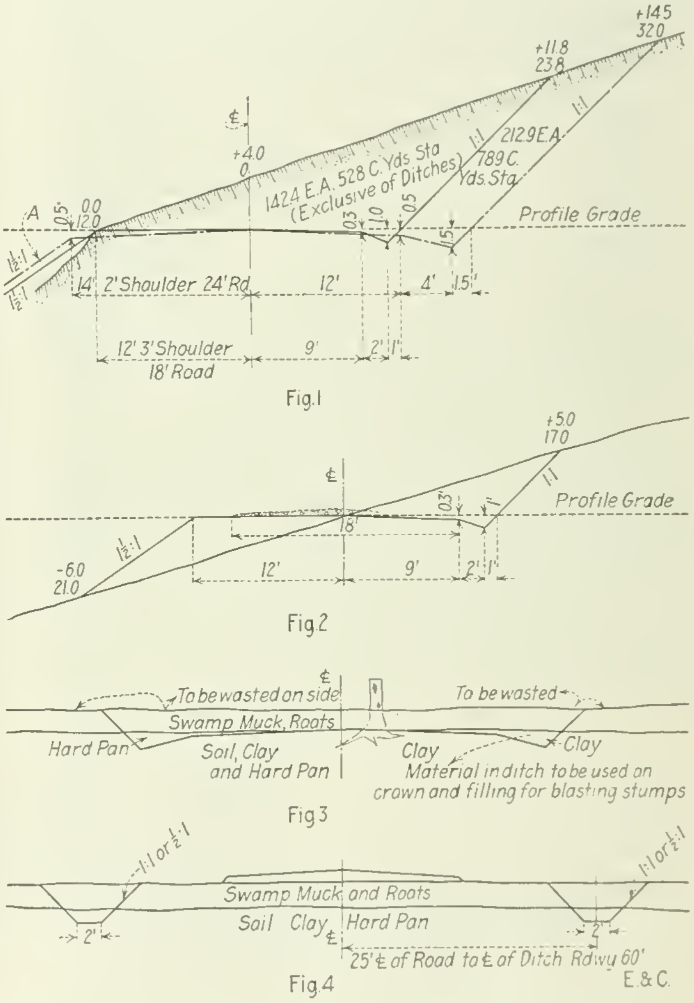
At times undue emphasis has been placed on roads between large trade centers. Here in a great number of cases existing roads can be revised to suit the new highway conditions at a nominal cost. The farming communities that are without rail facilities are the ones in most urgent need of good roads.

"All the mileage the money will build." If we accept this as a criterion, the economic width or section of the proposed roadway is the all important decision on which success or failure rests.

Previous to the "Good Roads" movement all of the western country was served with roads varying from 8 to 12 ft. in width. It was a first class highway that had 14 ft. width of hard surface. In laying out new roads the movement has gone to the other extreme, it is not uncommon to find a 12 ft. road serving a community suddenly improved to a 24 ft. road or even to a 28 ft. road.

Where the road is being built by a bond issue an 18 ft. road is adequate for all purposes. This allows two of the largest motor trucks to pass with 5 ft. clearance.

Fig. 1 shows the relative quantities involved in an 18 and 24 ft. road. The excavation quantities are 50% more than the 18 ft. road. The net gain for this heavy increase in construction cost is practically nothing, as the two embankments will show at point A, fig. 1. The 18 ft. road has a 3 ft. shoulder on embankment, making the subgrade 24 ft. in width, substantially the same results being obtained as on the 24 ft. road, for a road is no wider than its narrowest part. The 3 ft. shoulder has been made necessary by the vibration and sliding of heavily loaded motor trucks.



Figs. 1 to 4—Diagrams Illustrating Economic Road Sections.

Everything else being equal a much better location can be made on an 18 ft. road than on a 24 ft. road. With less excavation quantities to handle controlling points can be "hit harder," and under nearly all conditions a better alinement is possible.

The right of way being purchased on a good alinement, the location of the road is settled. When traffic becomes too heavy for this road it can then be widened to good advantage. In the western country the difference between an 18 and 24 ft. road is this, one community has more road than it can use, whilst another has none.

A 24 ft. road will cost from 25 to 40 per cent more than an 18 ft. road. This heavy increase of construction costs is not justified by present conditions of development, traffic requirements or the small net gain of width on embankments (see A, Fig. 1).

The ditch section on the 18 ft. roadway is 3 ft. in width by 1 ft. in depth. It is practically the same section in use by the railroads, where water is often brought much greater distances than is common on highway work, along a minimum grade. Road supervisors should be especially impressed to keep the ditches cleaned out.

The embankment for the 18 ft. road is to be finished level. There is nothing gained by "crowning" a new fill. There is a natural settlement along the side slopes, and as ruts wear into the center, and the center sinks under traffic, the drag soon makes a crown. If it is arbitrarily crowned when first completed, graveling and the use of a drag or grader soon makes the crown excessive, causing passing motor trucks to slide over on the shoulder.

In excavation the grade at 9 ft. out from center is 0.3 below profile grade, and at 11 ft. out is 1 ft. below profile grade. Slope stakes to be set to profile grade. The custom of setting stakes in reference to the bottom of the ditch is confusing to graders. The small quantity in the ditch of 12 cubic yards to the station can be distributed over the fill for shrinkage or be considered a factor of safety on balancing quantities.

Although Fig. 2 shows an 18 ft. road there is room for a 20 ft. pavement in this section if necessary.

It is always an advantage to build the road as much as possible in excavation. It results in a better and safer roadway and to all practical purposes is a wider one than on the embankment section. To gain these advantages it is often profitable to waste quantities in light scratch work. Material should not be hauled merely for the sake of hauling it. There is no reason for making a fetish out of balanced quantities. A draftsman can balance a cut or fill but it requires experience to waste quantities to advantage. The use of the word "waste" is a misnomer under such conditions.

Roadbuilding in Swamps.

The construction of a road through a swamp is nearly always attended with difficulties. Swamps are of two kinds. (1) Those which are due to defective drainage, causing from one to two feet of moss rotten vegetation and muck to form over a good soil. (2) True swamps, where there is very little drainage, the water seeping away through the muck which varies from five to fifty or more feet in depth. The best way to treat swamp I is to build the road through it in cut, as shown in Fig. 3. This has several advantages.

1st. The roadbed is more solid than an embankment made of this class of material would be, for gravel or crushed rock dumped on 1 to 2 ft. of muck will work down to a good foundation.

2nd. The side ditches forming a part of the road will always be maintained.

3rd. It gives a wider roadway.

In constructing a road over a true swamp the embankments should be at least 2 ft. in depth. Three or four feet is the ideal height. The original mattress of brush should not be disturbed. The stumps should be cut close to the ground. A fill of three feet as a general rule will not require side ditches. Culverts wherever a small flow is encountered being all that is required. This is the usual method followed on railroad construction.

The poorest roadbed is where the grade line makes a fill of a few tenths or a foot across a small swamp in a distance too short to enable the grade line to be changed. In these cases side ditches must be built as shown in Fig. 4. A ditch with a bottom width of 2 feet and varying depth from 1 to 3 ft. according to the ditch grade line will give good results. The worst feature of these side ditches is that they are not a part of the road and are neglected! These ditches will soon grow up solid with whatever is the characteristic growth of the swamp.

In building the road through swamp No. 1, the material in the bottom of the ditches will generally be found suitable for the sub-grade. Instead of wasting this ditch quantity it should be cast into the center of the road. Road building through a swamp requires the best attention and judgment of the engineer in charge. The material and conditions are so variable that hard and fast rules cannot be laid down. The tyro in engineering can build a good road through dry sections, but it is impossible to have too much experience in constructing roads through swamps and in slides. Many highway engineers seem to encounter difficulties with the special problems of highway work. The bias of railroading is hard to overcome. In railway and highway locations there are practically no factors in common. The surface is more of a controlling factor than grade. Engineers make a grave mistake in locating a highway as if it were a cheap branch line or logging road. Comparisons if not odious are often dangerous. A highway is far from being a trackless railway. Railway location is a science; highway location is a fine art.

WATER WORKS

EXPERIENCE WITH THE DIESEL ENGINE IN THE MUNICIPAL POWER PLANT OF PALO ALTO, CALIF.*

By J. F. Byxbee, Jr., City Engineer, Palo Alto, Calif.

The Palo Alto Municipal Power Plant furnishes power, light and heat to a city of some 5,500 inhabitants, and has at the present time a total of 1,480 active commercial services. It also furnishes power for the municipal water and garbage destructor plants.

Prior to the time of the Diesel engine installation, the plant consisted of a steam electric generating station of a total of 485 K.W. capacity. There were four boilers with a total rating of 760 HP., and four non-condensing steam engines of 800-HP. direct-connected and belted to four 60-cycle 2-phase alternating current generators.

The yearly output of the station at present is approximately 1,140,000 K.W.-hrs. The average load factor is 40 per cent, and the average peak load about 360 K.W. These figures vary greatly in the different seasons of the year and affect the economy of the station as it is now operated to a very considerable degree. A diagram was made showing the fuel oil consumption per kilowatt hour for the various steam engines of the plant working singly or together at different loads. From these curves it was seen that the steam plant is very inefficient as far as fuel oil is concerned, especially at low load. The average steam plant economy is about 1.75 K.W.-hrs. per gallon of fuel oil.

In 1912 the Board of Public Works determined upon the purchase of some new machinery for the plant for the purpose of increasing the capacity somewhat, and also to replace one steam engine that was worn out and very uneconomical to operate. The idea at that time was to put in a steam turbine of about 500 K.W. capacity with condensing equipment, the cost of which would be about $19,000, not including boiler. Bonds were issued for this improvement and bids received on a number of different propositions, including gas, steam, Diesel engines and steam turbines. After reviewing the tenders we were particularly well impressed with the gas and Diesel engines, and finally awarded a contract for a gas engine of 450-B.H.P. direct connected to a generator of 300 K.V.A. capacity. The steam turbine, while offering a considerable increase in capacity, did not appeal to us, as with our existing load conditions it would be very inefficient to operate, and even at full load a turbine of small capacity is not an economical prime mover.

After letting the contract for the gas engine, the company to whom the award was made suffered some financial reverses and the machinery was not delivered.

In June, 1913, the Board of Public Works again received bids on Diesel engines alone from the following concerns: Koerting Bros. Co. of Germany, Lyons Atlas

---

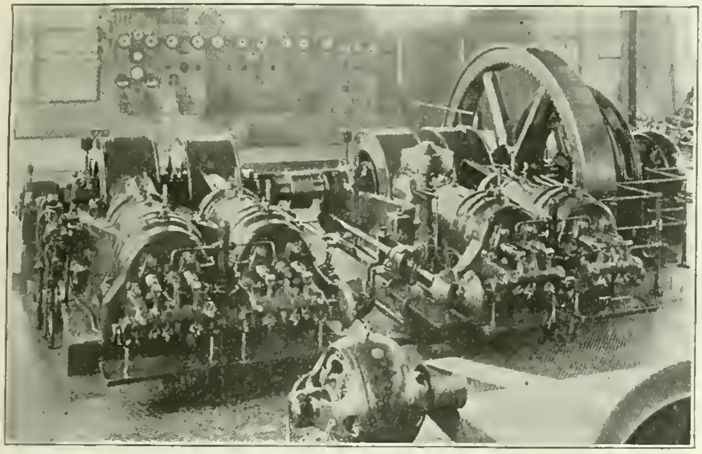
*Paper read before 1915 annual convention of League of California Municipalities.

Co., Snow Steam Pump Works, Carels Diesel Engine Co. of Belgium.

Before accepting any of the above propositions, Mr. Youens, our City Electrician and Mechanical Engineer, was sent to a number of places in the United States to study personally the operation of various Diesel engine plants, and as a result of his investigation he recommended the Koerting Diesel engine, one of which machines he observed in operation at the Bosch Magneto Works, Springfield, Mass. The Board of Public Works accepted his report and recommendations, and appointed R. E. Mathot of Brussels, Belgium, a consulting engineer and well known Diesel engine expert, to supervise the construction of the engine.

The engine arrived in Palo Alto about Aug. 1, 1914, and was erected on its foundation, ready to operate, by Nov. 1, 1914, but during that month no special effort was made to put the machine in service, as it was subjected most of the time to testing and adjusting. Since Dec. 1, 1914, it has been in almost constant operation, carrying the main load of the power station, and has afforded us a good opportunity to study its characteristics.

Economical Selection.—There are a number of things to consider in the selection of a prime mover for any particular service, such as first cost, fuel consumption, supplies, lubricating oil, water, repairs, attendants, general reliability, regulation, life of the apparatus and the kind of work it is to perform. Any municipality considering the installation of an electric generating station will have its own problems to solve regarding the selection of machinery, as what would be the best machine for one situation might possibly be a losing proposition for another. In the Palo Alto case, the selection of the Diesel engine seemed advisable. The city required 200 to 300 K.W. additional capacity at the station. A 200-K.W. machine operating continuously would have an average load factor of between 50 to 60 per cent. If the addition consisted of a Diesel engine the operating cost of the station would be the present cost of operation plus fixed charges on the new unit, less approximately $6,000, which sum represents the saving that would be made in fuel oil consumption after the Diesel engine was installed. Considering the fuel oil economy alone, and allowing 5 per cent interest on a $30,000 investment, and 5 per cent depreciation charge, the Diesel engine would show a saving in plant operation of approximately $3,000 per year, while a steam plant of about the same size, with boiler and auxiliaries, costing say $20,000, and with interest and depreciation at 5 per cent each, would show a loss in plant operation of approximately $1,000 a year; therefore, from this point of view, the Diesel engine would be the better purchase even though the first cost is greater. As the load at the station increases, the Diesel engine would show to even better advantage than the above figures indicate, though another machine of that character should be purchased before the present steam plant again assumes a large portion of the load.


View of Diesel Engine in Palo Alto Municipal Power Plant.

Efficiency.—There is no question about the efficiency of the Diesel engine as regards fuel oil consumption. The Palo Alto machine, under test with Richmond fuel oil of 17,741 B.T.U. low heat value, gave the following results:

At full load—
0.388 lb. per B.H.P. equals 0.0492 gal.
At three-quarter load—
0.385 lb. per B.H.P. equals 0.0487 gal.
At one-half load—
0.439 lb. per B.H.P. equals 0.0556 gal.

In the ordinary operation of the plant we find the machine to give from 9 to 12 K.W.-hrs. per gallon of fuel oil at the switchboard, depending upon the load conditions during the time the measurements are taken. Thus far, September, 1915, the efficiency of the machine does not seem to have decreased appreciably through usage, but I presume that as the parts become worn there will be some losses.

The station economy in kilowatt hours' output per gallon of fuel oil, taken month by month since the Diesel engine was installed, is as follows:

Month—	K. W.-hrs. per gal of fuel oil.
Before installing Diesel engine	1.75
November	2.02
December	3.39
January	4.21
February	3.55
March	3.78
April	4.08
May	4.60
June	5.58
July	5.49
August	5.10

The reason that the station economy compares so unfavorably with the Diesel engine economy is due to the fact that one or more of the boilers is maintained under pressure at all times in order to hold the steam plant ready to take the load quickly if anything should happen to the Diesel engine, and also to have available at any time additional power for sudden increase in the load, or to furnish steam for the steam fire pumps; also the operation of the steam engine for from two to four hours over the peak load each evening and during the time that the Diesel engine is laid up for cleaning and repairs, cuts down the station economy very materially.

Fuel.—The fuel used is what is known as Richmond Fuel Oil, the same as is burned under the boilers of the steam plant. Its composition is about as follows:

Specific gravity at 15° C	0.95
Baumé equivalent	15.9°
Water and dirt	trace
Sulphur	0.776%
Fuel valve	18,000 B.T.U.

In Diesel engines using the needle type of injection valves, it would be difficult to use this fuel successfully, but with the injection valve adopted by the Koerting engine, the oil is handled quite readily, especially when heated to a point where it will flow easily. In this injector the oil is pumped under low pressure into a receptacle behind a check valve separating it from the cylinder. At the proper time high pressure air is admitted to this chamber and blows the oil through the check valve and a nozzle on the end of the injector into the cylinder, where it is immediately ignited by the high temperature of the air compressed in the cylinder.

The fuel oil tank is water jacketed for hot water, also the fuel oil pipes leading from the tank to the injectors. The water supplied to these jackets is warm water taken from the cylinder water jackets.

It is necessary to use a light oil, such as Calol fuel oil of about 24° Baume when starting the engine cold.

Supplies.—Thus far the cost for miscellaneous supplies, such as packing, waste and other minor material used about a power station, has been lessened since the installation of the Diesel engine. Such an engine practically eliminates packing, as most joints are ground joints, and there are no stuffing boxes of any considerable size or importance. There are a few copper asbestos gaskets, but these are small and long-lived, so their cost is insignificant.

Lubricating Oil.—The crank shaft and connecting rod bearings of this engine are lubricated by an oil circulating system, consisting of a pump, reservoir, cooler and strainer. The reservoir was originally filled with Renown engine oil, but is now being replaced with oil which overflows from the cylinder and piston lubrication, and with filtered oils. The cam shaft bearings all have reservoirs and ring oilers, and all gears run in oil, so that it is seldom necessary to give these parts any attention.

The air compressor and connecting rod wrist pins and cylinders of the engine are lubricated at present with what is known as Calol Diesel engine oil and Zerolene, made by the Standard Oil Co. We are using an average of 5 gal. per day of these oils, costing 35 ct. per gallon. The cost of lubricating oils required for the station has increased approximately $10 per month since installing the Diesel engine.

We have had considerable trouble in securing a suitable lubricant for the cylinders of the Diesel engine, and have experimented with a number of different makes, but thus far have found the above mentioned lubricants to be the best, though they do not give entire satisfaction.

Water.—Approximately 2,000 gal. of water per hour are used for cooling the engine. This figure varies to a considerable extent with the load. Waste of water is greatly reduced by the use of a small cooling tower.

The pump for this circulating water cooling system requires 1.66 K.W. or about 1,200 K.W.-hrs. per month. The station now uses approximately 275,000 gal. per month less for operation than when it was purely a steam plant. At 12 ct. per 1,000 gal. water cost, and allowing 1 ct. per K.W.-hr. for current lost in circulating cooling water system, the water cost to station is about $21 less per month than formerly.

Repairs.—Outside of cleaning up exhaust valves, cylinders and pistons, repairs on the machine have been quite negligible. Up to the present time our worst trouble seems to be to keep the pistons clean enough to operate without sticking in the cylinders. We have adopted the practice of removing and cleaning each piston once every four weeks. The instructions that came with the engine stated that the pistons should be cleaned about once every three months, depending somewhat upon the nature of the fuel oil, but our experience has been that the machine would not run that long without cleaning. I have often heard Diesel engine operators and salesmen say that they do not clean the pistons of their machines more often than about once a year, so we are somewhat puzzled over the situation. Either these men have not an accurate record of the operations of their engines, or else the design of their particular machine is such as to give cleaner operation than the Palo Alto engine gives. We have reviewed these matters with the factory, but up to the present time have not arrived at any solution of the difficulty. Under the circumstances it is fortunate that the engine is of the horizontal type, which permits of easy withdrawal of the pistons. Four men can withdraw, clean and replace the four pistons in less than twelve hours. Our practice is to shut the engine down about eight hours each week to clean one piston and two exhaust valves and do such other work as may seem necessary. Besides this work the record for repairs is as follows:

Time.	Hours out of service.	Trouble.
Dec. 2, 1914.....	3	Injection valve stuck.
Dec. 7, 8, 9......	72	Broken gear in lubricating pump.
Dec. 11, 12......	28	Changing air inlet to air compressor.
Dec. 19, 20......	24	Piston No. 2 stuck. Taken out and cleaned.
Dec. 21..........	18	High pressure piston rings of air compressor worn out.
Jan. 4, 1915.....	20	Piston No. 4 stuck; engine cleaned.
Feb. 24..........	9	False head of No. 3 piston renewed.
March 27.......	3	Broken valve in low stage of air compressor.
May 3...........	8	Lubricating oil pipe stopped up.
July 18, 19, 20, 21	96	Piston No. 3 stuck. Engine cleaned.
Aug. 16..........	3	Valve in high stage of air compressor stuck.

No particular trouble has been experienced with the high pressure air system. The valves, fittings, piping and air compressor seem to be very capable of withstanding high pressures. The injection pressure is often maintained at 1,050 lb. per square inch, though at low loads it is generally reduced to 900 lb. per square inch.

No soot has accumulated in the mufflers or exhaust pipes.

From Dec. 1, 1914, to Sept. 1, 1915, the engine has operated 5,980 hours, or 91 per cent of the total time. Of the time the machine was shut down, 312 hours were for the regular cleaning periods, and 284 hours for repairs and extraordinary cleaning.

Regulation.—The regulation of the Diesel engine generator set under ordinary load conditions is very satisfactory, even better than that of the steam engines of the station. We have not the slightest difficulty in operating the Diesel engine generator in parallel with any or all of the other steam-driven generators.

Attendants.—The operating force at the plant is the same as before the Diesel engine was installed. The steam engineers apparently had no difficulty in handling this new type of machine, even though their instructions were very meagre. The erecting engineer could only speak English, which language was not understood by those operating the station.

The Diesel engine in operation requires closer attention than a steam engine, and I am of the opinion that while no firemen are needed for such a plant, their expense would not be eliminated, as without doubt extra attendants would be required in large Diesel installations.

General Reliability.—From our experience we would say that the Diesel engine plant is not as reliable as the steam engine plant, though in case of breakdowns it is possible to start up another Diesel engine and take the load very much quicker than it is to start a steam engine, especially where any additional heating up of boilers is required. The Palo Alto machine is started and the load taken on ordinarily in three minutes. Since operating this engine it has stopped on five different occasions so suddenly as not to give sufficient time to transfer the load to some other machine. On three occasions this sudden stoppage was due to the sticking of the pistons, once through the sticking of the injection valve, which let the high pressure air out of the tanks, and once because of the sticking of a valve in the air compressor.

During the first few months considerable trouble was experienced through the sticking of the exhaust valves, which would temporarily incapacitate one cylinder, but this trouble did not interfere with the engine carrying the load, for it would manage to limp along on the other three cylinders until the valve was loosened, which operation would take perhaps several minutes. The valve stems seem to have been fitted too tight in their sockets.

The Diesel engine does not act as well as the steam engine when frequent "shorts" occur on the line, which cause the load to be suddenly released or put on. It smokes considerably at such times and seems to regulate so poorly that the operators prefer to cut the engine out and use the steam plant. We were troubled twice this last winter that way for a few hours, but presume that if there had been no other machine available we could have gotten through with the Diesel, but as it was, the engineers thought it safer to leave it alone while it was acting in this rather cranky manner.

Life.—My opinion is that the machine should last 20 years if it is given good attention. Thus far we have found no part of the engine which has indications of being fundamentally weak. The design is very liberal and all parts run smoothly. There will be replacement of parts and cylinder liners required, but from the present indications this work will not have to be done often, so the repair expense should not be heavy even after a long period of use.

In concluding these remarks I wish to make the following general statements:

1. The Diesel engine as now developed is a reasonably dependable and economical prime mover.

2. The European machines, at least at the time we received bids, were better than the American products, though with the more general manufacture of this type of engine in the United States, I see no reason why the American makes should not ultimately excel. Great care should be exercised in the selection of the American machine at this time, as some companies do not seem to possess safe engineering principles and will guarantee almost anything in order to sell their product.

3. Due to the inefficiency of the small or moderate

sized steam engines and turbines, they cannot even be classed as competitors of the Diesel engine where fuel oil is used and where load factors are of sufficient moment to seriously consider fuel economy.

Nearly all steam electric generating stations in this State giving a 24-hr. service would save some 50 per cent of their fuel oil if a Diesel engine of sufficient size to carry practically all of the off-peak load were operated in conjunction with the steam plant. In dollars and cents the saving would be approximately 25 per cent of their present cost of fuel oil after making the proper interest and depreciation allowance on the Diesel engine installation. This matter is a serious one and deserves our careful consideration. Any machine that will eliminate waste of oil and thus tend to conserve the petroleums of this State, and at the same time operate with reasonable reliability, such as the Diesel engine will, should certainly be received with favor.

The actual fuel cost of operating the Diesel engine is about two mills per kilowatt hour, and to that we have to add interest and depreciation and attendance on the plant. In our case, our fuel oil bill was originally about $12,000 a year. It has been reduced to $6,000 a year through the installation of the Diesel engine.

SOME EXPERIENCES IN WASHING RAPID SAND FILTERS IN NEW JERSEY.*

By Francis E. Daniels, Director of Water and Sewerage Inspection, New Jersey State Board of Health.

The proper washing of filters is a problem which must be solved for every plant as many purely local conditions always present themselves.

Washing Gravity Filters.

There are three different methods of washing rapid sand filters in use in New Jersey: (1) Reverse current of wash water, with mechanical agitation by means of a revolving rake; (2) reverse current of wash water alone; (3) reverse current of wash water and agitation by compressed air. There are two methods of air and water wash, one with separate manifold distribution systems for air and water, and the other with a combined manifold distribution system.

(1) The method of wash with reverse current and agitation with rakes is only applicable to circular filters, as the sand is agitated by prongs of a rake in the sand bed, which usually extend through the bed of sand to the gravel. Power for revolving the rake is transmitted by a belt and pulley. Although a good wash is generally obtained with this method, on account of the extra power required and the necessity for circular construction of the filters, few plants are so equipped, except perhaps some small installations. The sand must be thoroughly broken up and agitated during the time the reverse current of water is flowing, or else the bed will not be washed evenly.

(2) There are several plants in the State using the reverse current method, some giving good and others poor results. If proper piping has been installed, and the wash water is furnished in sufficient quantity, at a proper velocity and is evenly distributed in the bed, good results will be obtained. The wash water should be furnished so that a vertical rise of at least 15 in. per minute is obtained. In this as well as in other methods the sand should be lifted and kept in a suspended condition during the washing. Should the bed not break up evenly the attendant can often assist by means of a rake or paddle.

(3) The method of washing with a reverse current of water, assisted by compressed air, to break up the bed so that the water may do its work more effectively, is in use at a good many New Jersey plants. Plants using a separate system of air and water pipes and ones in which air and water are both supplied through the same system, are in use. With this method the vertical rise of wash water can be somewhat less than in the preceding method, although it is very essential that the bed break up evenly and that the sand is entirely suspended.

There has been considerable trouble experienced in washing filters properly. In several instances it has been due to the inability of the drains and waste line to remove the wash water fast enough. In other cases sufficient wash water could not be supplied for washing. A velocity equivalent to a vertical rise of 15 to 18 in. per minute is required for washing filters where no other means of agitation is employed and 12 to 15 in. per minute when a method of agitation is used. Another source of difficulty is in the manifold distribution system. In some cases this is due to the uneven distribution as well as the lack of a sufficient number of strainers, while in other cases to the clogging of the strainers. Wash troughs too widely spaced will hinder the mud from flowing away and much will settle back upon the sand.

The results of poor washing can and should be readily noticed by the attendant. In many instances an examination of the sand bed will show such characteristics as mud balls, cracks in the sand, patches of dirt on the bed after washing, and a considerable layer of dirt over the entire bed after washing. The attendant on observing any of these conditions should investigate, and, if possible, remove the cause immediately, because if allowed to continue the filter will need to be completely overhauled.

Washing Pressure Filters.

The washing of pressure filters has not received the attention given to the gravity filters. This is probably due to the fact that conditions in washing filters of the latter type are more easily observed, and the faults noticed and studied systematically. However, much attention and study should be given to the washing of pressure filters, because the sand bed is not visible. The attendant should remove hand hole or man hole plates quite frequently, and examine the condition of the sand bed both during and after washing, so that he may know exactly the condition of the filtering material. It has been observed at several plants in this State, on opening the pressure filters, that the layer of sand adjacent to the steel shell was cemented together with aluminum hydrate.

At Bound Brook the pressure filters became clogged to such a degree that to obtain good results, it may be necessary to remove the sand and gravel from the filters for a complete cleaning. At this same plant raw water is very often used to wash the filters, and as this water is turbid at times, and is treated with alumnium sulphate, there is danger of clogging the strainer system, and impregnating the entire sand bed with foreign material.

A decided improvement in pressure filter construction has been observed at the plant of the Monmouth County Water Co. at Asbury Park. During 1914 the pressure filters were completely overhauled, new strainer systems installed, and the sides and bottoms of the filters have been lined with concrete. These improvements were to eliminate several of the faults mentioned above, and they tend to make the filters similar to rapid sand filters of the gravity type.

GROUND WATER SUPPLIES TREATED FOR CARBON DIOXIDE REMOVAL IN NEW JERSEY.*

By Francis E. Daniels, Director of Water and Sewerage Inspection, New Jersey State Board of Health.

On account of red water troubles in Cranbury, N. J., a lime treatment plant was installed to remove the free carbon dioxide which is present in the well water. The pump formerly drew the water from the well and forced it under pressure directly into the distribution system, and only a slight excess was sent up into the elevated storage tank. The amount of carbon dioxide was considerable, and it did not have a chance to escape until the water was drawn at the faucets in the houses. Trouble was experienced with the rusty water, and it was believed that it was caused solely by the carbon dioxide rusting the pipes, since the iron content of the water in the well was practically zero. The case was put in the hands of a water treatment company and a lime plant installed. The complaints ceased almost immediately and apparently the plant was a success.

---

*From recently published 1914 annual report of New Jersey State Board of Health.

*From recently published 1914 annual report of New Jersey State Board of Health.

When further tests were made on this plant it was noted that no provision had been made for settling out the carbonate of lime formed, as everything was forced into the distribution system. The question of deposits in the pipes was then raised, and also whether or not deposits and rusting might occur in the hot water systems by the action of heat on any bi-carbonates which might be formed should the operation not be properly controlled. Simple aeration on a small scale was tried, with the result that about the same amount of carbon dioxide was removed by that means as with the lime.

The company was then advised to consider aeration, using an extra riser to convey the entire supply to the tank, and after aeration to distribute from the tank with perhaps lime treatment for the carbon dioxide still remaining.

It is believed that in the future more attention will be paid to the elimination of carbon dioxide both in ground waters and in filtered waters purified by the use of alum. A water heavily charged with dissolved oxygen, which is treated with alum and put through a system of pressure filters directly into the distribution system, is likely to cause considerable trouble from red water.

A DISCUSSION OF 14 IMPORTANT FEATURES OF WATER WORKS OPERATION—MONTANA REGULATIONS GOVERNING WATER SERVICE.

Because there was a decided lack of uniformity in water rates in Montana, where the conditions were not apparently dissimilar, and because of a desire to be further informed on this and closely related matters, it was ordered that a public hearing be held in the offices of the Public Service Commission of Montana, at which all water utilities were given opportunity to show cause why rules and regulations to govern and standardize the supplying of water should not be issued. Fourteen major features of the procedure in water works operation were considered critically and then the rules and regulations were formulated. The essential features of the discussion and of the rules and regulations are here given as based on report No. 131 of the Public Service Commission of Montana.

Discussion.

(1) Provision, Installation and Maintenance of Service Pipes.—It would appear, casually, that the utility should not only lay its mains, but should also lay and maintain the service pipes in the public streets as a part of its permanent plant. The question is asked: "Are service pipes not essential to the distribution of the utility's product, and could the utility perform its obligations to the public without them? Why, then, should the consumer be called upon to furnish a part of the equipment, which differs from the mains only in regard to size of the pipes; the two combining to form a complete distribution system?"

Reviewing the action taken by commissions in other states and decisions handed down by various courts, we find many reasons advanced both for and against complete ownership by the utility. It is probably true that the latter can furnish the material and perform the labor with its organized forces for less money than the individual, who, generally speaking, has a very limited knowledge of such things and must depend entirely upon the contractor whom he employs. There is not, however, enough capital involved to make the difference in cost a determining factor. It is estimated that the average cost of furnishing and laying the necessary pipe line beyond the main (service pipe) is about $40; the life of pipe varying considerably, depending upon the nature of the soil and mineral properties with which it comes in contact. It may be said that the average is in the neighborhood of 20 years. This estimate is exclusive of cast iron and lead services, as they are not in general use in Montana.

To throw additional light upon the question it might not be amiss to quote the following from the testimony given by Mr. Eugene Carroll, Manager, Butte City Water Company:

> We have in Butte 9,500 house connections, in round numbers. Those house connections have a reasonable, full and very low value of $50 per connection, which would make $475,000 invested in house connections in the city of Butte, approximately, at this time. We maintain that a fair depreciation from our experience in Butte, on pipes laid in the ground, is 4 per cent annually. We say that is the depreciation on our large pipes. The depreciation on the small pipes would possibly be the same; may be a little more. So it is 4 per cent, then, the annual depreciation, and that investment at the present time is $19,000 a year on the total depreciation.
>
> Now, presuming that we were ordered from now on to make the house connections at the expense of the utility, we would then be held responsible for the pipes already in the ground, which have cost originally $475,000. Those pipes have been in the ground ranging from 30 years to 1 year, and it is fair to suppose that at least 15 years' average depreciation has taken place in those pipes. That would mean that 4 times 15 or 60 per cent of the original value of that investment has gone. Therefore, we should have to immediately increase our depreciation reserve by 60 per cent of the $475,000. In other words, we would immediately have to lay aside on this annual depreciation reserve $285,000, to take care of the maintenance of the pipes that are in already. We would then have to carry on our books this amount as a depreciation, in view of these pipes that are in the ground, and we would begin to charge 4 per cent annually on that, which would mean the addition to our depreciation reserve, which is annual, of $19,000.
>
> Now, the maintenance of those pipes that are already in the ground, the depreciation takes care of the renewal, but the actual maintenance on that would amount to probably two per cent, I should estimate somewhere between 2½ and 2 per cent of the value of the plant for the maintenance. The cost of maintaining those pipes, at say, two per cent would be $9,500 a year. Our operation costs, legitimate operation costs, would be immediately increased at the rate of $28,500 a year at those figures; and there would be no additional return to the utility for that amount of money. And if we are now earning only a fair return on our investment, the additional cost of $28,500 a year to our operation expense would work around to the proposition of the question of rates, and that our rates would not be sufficient to cover our just operation costs.
>
> This gets into figures even in a large plant like that at Butte, and I think the smaller plants will show you that it might absolutely bankrupt a small community to place this large additional cost on them. With Butte it would mean that immediately we would have to increase our depreciation reserve, or get securities worth $285,000 in cash. That is what it would mean to Butte, should such a rule be adopted, even not applying it to the former connections, but from now on.
>
> Now there is another idea that occurs to me on that line. Butte has pretty nearly reached its growth, so far as its water plant is concerned, and so far as the house connections are concerned. The improvements will not require additional house connections, and our 9,500 house connections at this time represent pretty close to our limit. We may increase 25 per cent in the next 10 years or 20 years; so that the present community has paid for these house connections. The new fellow that makes his house connection is having the community pay for that house connection, while the majority of the community have already paid that and are paying a second time to benefit some other consumer.

While the estimates on the original cost of the 9,500 house connections, depreciation and maintenance of same, submitted by Mr. Carroll, may be rather high, the fact remains that if the water utilities are required to install and maintain these service pipes, it necessarily follows that the investment in such facilities will increase to that extent its capitalization upon which it is entitled to earn a fair return, in addition to setting aside a sufficient amount annually to take care of depreciation. How is this additional revenue to be earned? The utility has nothing to sell but water, and there is no other avenue open to it except to increase its rates per month or per thousand gallons, as the case may be in an amount commensurate with the added investment; assuming, of course, that the present rates are not unreasonably high. Looking at it in this light, which we believe to be its true aspect, in the absence of a physical valuation of water utilities, we do not find that it would accrue to the benefit of the consumer to reverse the present general practice in the state.

Under these conditions, as we find them to exist, no order will be entered for the present. (Curb boxes are dealt with in Section No. 6.)

(2) Meters, Ownership.—It was the consensus of opinion, and in fact the practice of nearly all utilities, to furnish, place and own the meter. There appears to be no question as to the propriety of utility ownership; very little testimony was offered in opposition. Unquestionably the utility is in a better position to judge as to the type of meter best adapted to its use. A meter is not a permanent device. It requires frequent inspection and repairing. It is the utility's yard stick, so to speak, by which it measures out its wares to the customer. It is manifestly essential that the utility should have full control over meters, to do with them as it finds expedient, removing same from service temporarily to be tested, or for other reasons, or supplanting the obsolete machine by one of more modern construction. The right to do so would be vested in the utility by ownership, but not otherwise.

(3) **Meter Deposit.**—This question is much in the nature of extending credit. If the utility owns the meter and installs it on the premises of the customer, it is only reasonable to expect the latter to exercise proper care against freezing or being otherwise damaged while in his possession. In other words, the meter has been loaned to the customer under certain stipulated conditions, to serve a mutual purpose. The utilities explain that "there are all kinds of people," some (the greater portion) reliable, others totally indifferent, and while there would be no disposition to require a deposit from the former, they should be given this latitude, optional in the judgment of the management, to protect its property against failure to exercise ordinary diligence.

The Commission concurs in the position taken, but we are also of the opinion that the consumer thus required to put up a deposit is entitled to and should receive a reasonable rate of interest thereon.

(4) **Meter Rental.**—The preceding sections contemplate utility ownership of meters. The question is, should the consumer pay a rental for their use? All utilities provide a minimum charge, either direct or by a meter rental, according to the capacity of the latter, which is assessed even though no water is consumed during that month. It is conceded that a minimum charge is justified, for the reason that the utility is put to an uncertain amount of expense by its "readiness to serve" at all times. It is not thought necessary in this report to analyze the various items of expense on account of being prepared to supply water, even though none is used; the minimum charge to the consumer, however, is presumed to be arrived at on the basis of the investment, plus an arbitrary proportion of the operating and distribution cost. There is no information before the Commission at this time to indicate that utility ownership of meters would impose a burden demanding greater revenue, or that the present minimum charge should thereby be increased. It should be understood, however, that the Commission takes exception to "meter rental," and when necessary the Commission feels that the utility should protect itself by a reasonable minimum charge based on the size of meter and consumption of water.

In connection with the meter question the following testimony presented by Mr. G. C. Pruett, Superintendent of the Miles City Water Department, may be of interest to water utilities that are obliged to pump water by steam or other motive power:

> that by metering in a year's time we saved half of the cost of the installing meters. The utility can install it for half the price that the plumber would charge. This whole business gets back to the proposition of allowing the utility to make a rate to take care of the cost of depreciation. Now, we are metered up. It was necessary to meter; it wasn't because we wanted to at all, or anything of that kind, but we installed a new plant and thought that plant was good for several years on a flat schedule, but we found it wasn't. They were coming so strong on us we had to do something; we had to meter, and we found that it cut our consumption half; and we found
> approves the practice of making a charge for the privilege
> meters. In other words, it cost approximately $12,000 to meter, and we saved on the cost of power, on the cost of alum, on the cost of filtering, $6,000. The charges were such that we got the same revenue as under the flat rate schedule, but the saving in the cost of power and supplies was such in two years' time we are going to save the cost of the meters.

(5) **Meter Maintenance.**—This question appears to be fully covered in Section 2, wherein the Commission holds that the utility should maintain meters at its own expense.

(6) **Tapping Charge.**—There is probably less uniformity and more obscurity in regard to a "tapping charge" than any other feature of the service. The schedules on file with the Commission vary from $1 to $20, and in most cases no further information is given. That is, the Commission has not heretofore been apprised as to what this particular charge covers.

It develops from the investigation that in practice there is the same irregularly as disclosed by the schedules. In some cases the charge is an arbitrary amount assessed for the privilege of connecting with the main. Again, it seems that certain utilities furnish standard connections and install them at the consumer's expense, varying as to the size, and for which the latter pays a flat rate designated as a "tapping charge." It would appear to be the policy to furnish the curb box, curb cock, corporation cock and clamp (when the latter is used), and perform the labor of connecting with the main. It is important that these fittings be standard to each system, but not necessarily standard to all utilities. If each individual were permitted to make such connections as seemed to him best, there would be no uniformity and trouble would inevitably follow when it was found necessary to shut the water off or turn it on, for which purpose the utility is equipped with appliances conforming to its underground standards. It therefore follows that it is desirable to have that part of the work done by the utility.

In section one of this report the Commission has held that the service pipes are properly chargeable to the consumer. We are not of the opinion, however, that the latter should also pay the cost of tapping the main. The utility is financially benefited every time a tap is made, by adding another permanent customer to its list, and it would seem that the duty of the consumer should not begin until the main has been opened; in other words, when water has been placed at his disposal. It is therefore held that the utility should furnish and install at its own expense the necessary connection with the main, beyond which point the expense devolves upon the consumer; not at an arbitrary figure for the material furnished by the utility, but at actual cost.

It is perhaps needless to say that the Commission disapproves the practice of making a charge of the privilege of tapping the main where it is not shown that such charge represents either labor or material, or both.

(7) **Giving Notice of Shut-Off.**—While many utilities carry a rule that water would be shut off without notice, no testimony was offered in support of such a rule. It was quite generally agreed that notice should be given in advance whenever it were possible to do so. There will, of course, be emergency cases when this cannot be done.

(8) **Penalizing Delinquents.**—This section has reference to non-payment of bills, but not to penalties imposed for violation of rules. The utility may protect itself by requiring a deposit in an amount sufficient to cover the estimated usage. It may decline to serve a consumer in arrears by shutting the water off after due notice has been given. Certain utilities demand the payment of various sums in addition to the unpaid bills, before the water will again be turned on.

The utility is entitled to remuneration for the extra expense it has been put to. The charge should be no greater than will protect the company and must not place an unreasonable burden upon such users as may find themselves temporarily unable to meet their bills promptly. The Commission has authorized in the following order, a maximum charge of one dollar in such cases.

(9) **Refusing Service to Renters.**—The testimony submitted under this heading would indicate that the Commission contemplated relieving the owner from responsibility and placing it upon the tenant; such is not the case. It is quite the general practice of utilities to contract with the property owner, and when such contracts are entered into, both parties are bound by the provisions thereof, but it has heretofore been brought to our attention that service has been refused when applied for by a renter even after a cash guarantee had been tendered. As already stated the utility is entitled to protection against transients and other unknown applicants, and as in the case of "meter deposit" supra, a deposit may be required in advance. Having furnished security either by cash,

bond, or its equivalent, the utility cannot consistently further decline to render service.

The Supreme Court of Montana, 18 Mont. 199. State Ex Rel Milsted, Relator v. Butte City Water Co., Respondent, decided May 4, 1896; Mandamus to compel the respondent, defendant, to turn on the water for general use at a certain house in Butte; appeal from Second Judicial District, Silver Bow County, says:

> A water company organized under the statute for the purpose of supplying a city and its inhabitants with water, and having been granted a franchise for that purpose, assumes obligations of a public nature and must exercise its powers in a reasonable manner, and therefore, where the inhabitants of a city occupying premises as a tenant, and requiring water for general purposes, but whose lessor has refused to be responsible for water rents, requests the company to turn on the water at his premises and tenders payment in advance, the refusal of the company to do so, under a rule not to supply water to rented premises except on the personal responsibility of the owner, and that if the water was turned on the money tendered would be credited to the owner, is unreasonable.

(10) Additional Fixtures, Flat Rates.—When water is furnished at flat rates it is computed on basis of the number of faucets, or openings, installed. It has been argued that a consumer might put in an additional tap for convenience and not necessarily use any more water than before. It must be acknowledged that the consumption will be greater on premises where there are ten faucets than where there are only five, if for no other reason than the "convenience"; it therefore follows that the usage will be relatively higher from two taps than from one. As stated, flat rates vary accordingly to presumed consumption and the consumer is not justified in making any addition thereto without the knowledge and consent of the utility. Should he do so, he becomes indebted to the utility to the extent of the change in fixtures for the length of time in use, at the regular scale of rates provided for such service. If it is shown, however, that the act was deliberate and secretive, the utility might feel that it had cause for an action against the perpetration of fraud.

(11) Consumers Supplying Others.—The utility obligates itself to supply the needs of certain premises designated in its contract, and without assigning further reasons it would be manifestly unfair for the consumer to, in addition to his own needs, assume the right to supply others. This does not, of course, refer to an occasional bucket of water furnished as an accommodation in emergency cases, but to the general practice of allowing or permitting non subscribers free access to its use. To persist in so doing would be sufficient cause for the utility to shut the water off until such time as satisfactory arrangements had been made.

(12) May the Consumer Turn the Water On?—When the water has been shut off by the utility, a purpose is involved. It may be to prevent damage being done by flooding, it may be for non payment of bills, it may be to permit of inspection or repairs being made, in fact there are a great many reasons, and it should not be turned on except by the utility or by its direction.

(13) Fines.—Certain utilities provide in their tariffs that "fines" of various amounts, sometimes designated as "penalties" will be imposed for violation of rules. Earlier in this report the Commission has held that the utility has the right to protection against imposition, and may, for just cause. discontinue service; we are not of the opinion, however, that the authority is vested in the utility to assess a fine. The exercise of such judicial functions is bestowed only upon the courts.

(14) Extending Mains.—The necessity for extending mains to reach localities not already served, must be determined upon a presentation of facts. No hard and fast rule can be made to govern under all circumstances. Therefore a utility rule specifically setting forth the conditions that must obtain before an extension will be made, could not be approved by the Commission. Such rules should, therefore, be eliminated from the schedules.

Rules and Regulations Adopted.

(a) When a water utility adopts the meter system, meters will be supplied, installed, and maintained at the expense of the utility. If necessary to provide special location, such as meter boxes, it will be the duty of the consumer to do so. Any unusual piping required will also be at the consumer's expense. Meters which have been installed at consumer's expense will be taken over by the utility at the pro rata value, based upon length of time in service and present condition.

Upon a proper showing being made to the Commission that a utility is not financially able to assume the burden of acquiring meters already installed, and owned by the consumer, an order will be issued permitting the utility to purchase said meters at the pro rata value, based upon length of time in service, and present condition, paying for them in installments and refunding to consumer by means of a percentage allowance on the monthly or quarterly bills for water consumed. The entire indebtedness, however, must be liquidated within 2½ years.

If a consumer desires a meter installed and the utility is financially unable to comply with request, the consumer may purchase of the utility a standard meter, which the utility will install at its own expense, refunding the purchase price of meter, in the same manner as described in preceding paragraph, allowing interest on the investment to consumer, at the rate of 6 per cent per annum.

(b) If the utility requires a meter deposit in accordance with Section 3 of this report, the consumer who was required to make deposit will receive interest thereon at the rate of 6 per cent per annum.

(c) A utility may protect itself by a reasonable minimum charge based on the size of the meter and consumption of water.

(d) The utility at its own expense must tap the main and furnish the corporation cock, the clamp (when necessary), and any other material used or labor furnished in connection with the tapping of the main. Any other material used or labor furnished in connection with the installation of the service pipe or curb box to the property line of the consumer shall be billed against the consumer, not at an arbitrary charge, but at actual cost.

(e) Unless under conditions where it is not possible to do so, the utility must notify the consumer prior to shutting the water off.

(f) When the water has been shut off for cause, the utility shall not charge the consumer a greater sum than $1.00 for turning it on. This must not be indicated in the schedule as a "penalty," but is presumed to simply reimburse the utility for the extra expense to which it has been put.

(g) Should the consumer, not the owner of the property, desire service and tender the utility a deposit to guarantee payment of bills for a period not less than the customary billing period of the utility and in no event less than one month, the utility must accept such deposit and render the service applied for.

(h) A consumer must not add additional fixtures without the consent of the utility, when water is being furnished at flat rates.

(i) Consumers must not, without the consent of the utility, supply water to others.

(j) When the water has been shut off it should not be turned on except by the utility, or by its direction.

(k) The Commission will not authorize the assessment of "fines" or "penalties."

Work of the U. S. Geological Survey in 1915.—During the past year the U. S. Geological Survey completed geologic and topographic surveys in United States, Alaska, and Hawaii aggregating nearly 112,000 square miles. The items of increase over the work of the previous year include nearly 2,000 square miles more of detailed geologic mapping in the States and a net increase in Alaska of 5,000 square miles in the exploratory and reconnaissance topographic surveys as well as 1,400 square miles more of geologic surveys. The Survey also continued the stream gaging at 1,350 stations and classified about 23,000,000 acres of public land. It also furnished the general land office two special reports and published various bulletins and scientific, economic and statistical reports.

Engineering and Contracting

Devoted to the Economics of Civil Engineering Design and to Methods and Cost of Construction

EDITORS

H. P. Gillette C. S. Hill C. T. Murray S. C. Hadden C. W. Malcolm

Volume XLV. CHICAGO, ILL., JANUARY 19, 1916. Number 3

PLANNING RESUMED FOR A RAPID TRANSIT SUBWAY SYSTEM FOR CHICAGO.

The Committee on Local Transportation of the Chicago City Council has again attacked the problem of an underground rapid transit passenger railway system for Chicago. To plan the attack the Committee has engaged a commission of three engineers: Bion J. Arnold of Chicago and William Barclay Parsons and Robert Ridgeway of New York City. The commission is a strong one. Each member is an engineer of wide experience in city transportation and in underground railway construction. So far the new move toward "Chicago Subways" is decidedly encouraging. To provide the means necessary for effective work by the Commission and to make the work of the Commission constructive by actual building are succeeding steps. Will the advance continue with these steps or, as has been the experience in the past, will it cease with the printing of the experts' report?

It seems to be the experience of American cities, that subway rapid transit lines can be arrived at only by much futile labor. New York which now astounds the world with the liberality of its expenditure for underground railways puttered for years with plans and experts before the first line was built. From 1880 to 1890 the leaves of Vallombrosa were not more plentiful than plans for subways. After 1891, in which year the first rapid transit commission organized, there were six years of almost continuous discussing of plans and making of reports before constructive action came. Each plan was whipped from commissioners to bankers to politicians and home again and an apathetic public watched the running. Chicago's record falls but little short, in effort wasted, of the record of New York and it is precisely of the same character.

In 1902 the Chicago Council Committee on Local Transportation engaged Mr. Bion J. Arnold to report on the Chicago transportation problem including the building of subways. In 1904 the same committee engaged Mr. Geo. W. Jackson as engineer to plan a comprehensive system of subways. In 1908 the same committee employed Messrs. John Ericson and Thomas T. Johnston to report plans for subways. In 1910 Mr. Bion J. Arnold was appointed Chief Subway Engineer of Chicago to plan a comprehensive subway system. In 1912 the Harbor and Subway Commission composed of John Ericson, E. C. Shankland and James J. Reynolds was instructed by the council's committee to submit plans for subways. Each of these engineers or commissioners in turn submitted one or more reports with more or less complete plans and cost estimates. At intervals between, plans have been reported by engineers employed by public organizations or by individuals. In a period of 14 years at least seven reports outlining a system of subways for Chicago have been prepared at great cost and without result in shape of even a first accomplished step toward financing or construction.

For a dozen years rapid transit subway construction has been the shibboleth of every mayoralty candidate and every candidate for alderman of the city of Chicago. Each new mayor has redeemed his pledges by an investigation and a report or two on subway plans by expert engineers. It may be quite possible that a new study of the problem and new plans for its solution are advisable, but the greater need is for a coalition of political and financial and business interests which will make possible actual subway construction.

A CURB ON COMMERCIALISM BY THE STATE CONTROL OF ENGINEERING.

While the state control of engineering work imposes certain restrictions which are likely to prove somewhat irksome and burdensome to the practitioner at times, such control really sets the engineer free from the hampering influence of the sort of commercialism which leads to slender designs and unsafe structures at low costs. While this thought has been expressed before it was advanced more as a prophecy than as a fact. That it is a fact has been brought out in connection with the experience of the Water Supply Commission of Pennsylvania in the regulation of the design, construction, operation and maintenance of all dams in that State. Such control has been exercised since the middle of 1913.

There are about 400 dams in Pennsylvania, the storage, height or location of which is such that failure might result in loss of life or damage to property. On examination about one in five was found deficient.

In passing on plans and specifications for proposed dams the Commission assigns first weight to stability. Economy of design is held to be closely related to stability and is given due weight.

The following quotation from the 1914 annual report of the Commission shows how that body comes to the aid of the engineer by freeing him from the cost limitation pressure so often brought to bear by owners:

> Proper factors of safety should be applied to all elements entering into the construction of a dam. The safety factor in an engineering design is an acknowledgment that uncertainties and contingencies are involved, which lie beyond the scope of human intelligence to estimate accurately and which must be provided for in a more or less arbitrary manner. These uncertainties enter into the design of dams, as into nearly all hydraulic construction, and this fact has not always received adequate recognition. Further, the element of commercialism may influence, to a certain extent, the values of safety factors. The Water Supply Commission, by insisting upon high standards of design, will, to a large extent, relieve the average practicing engineer from the harmful influence of commercialism, and permit him to apply his best judgment, to the end that the construction of all dams in the State will be of a higher grade than has heretofore in all cases obtained.

That this harmful influence of commercialism has not infrequently been imposed upon engineers by their hard-headed (and sometimes hard-hearted) clients is well known. In fact the state control of dam engineering in Pennsylvania was undertaken shortly after the latest notable dam disaster in that State. The designer of that particular dam had two conditions imposed by his client: minimum cost and maximum height.

While engineers have usually managed skilfully to maintain a balance between minimum cost and maximum height there have been not a few cases in which the cost paring process has led to disaster. While it may satisfy some to say that the engineer should not be unduly influenced by his client in this matter the fact remains that oftentimes he is. He is, first of all, human and usually needs work. When a man needs work he is constrained to push aside many polite fictions. His failure or refusal to provide a structure at a predetermined cost may mean that the cost limitation will be raised or it may mean that he will be dismissed in favor of another engineer who is willing to keep within the fixed cost. It is where the latter disposition exists that the backing of a state commission enables the engineer to insist upon an appropriation large enough to meet the cost of an amply safe structure.

COMPETENT OPERATION OF SEWAGE TREATMENT AND WATER PURIFICATION PLANTS PAYS THROUGH EXTENDING USEFUL LIFE OF PLANT.

Much of the lamentation evoked by the incompetent operation of sewage treatment and water purification plants has centered on the failure to secure under such management effluents of the proper degree of purity. Not much has been said about the financial aspects of the subject, from the standpoint of the plant owner, with the exception of possible damage suits arising from the creation of a nuisance, in one case, and from the creation of illness among consumers in the other case. There have recently come to the editor's attention two illuminating examples of the money value of competent operation of plants from the standpoint of the owner. This value arises from the extension of the useful life of a plant by competent management. The examples are here given. The first, relating to sewage plant operation, is quoted as follows from the latest published annual report of the New Jersey State Board of Health:

> To obtain the highest degree of efficiency from a sewage disposal plant, each unit should be tested at frequent intervals from the physical, chemical, and bacteriological standpoint. These tests can only be made by a trained man understanding the processes involved, and having a working knowledge of chemistry and bacteriology. When a trained man is in charge, the increased efficiency and longer life of the various units of the plant will, from a financial standpoint, more than offset the increased maintenance charges due to the manager's salary.
>
> A very good case in point has long been of interest. Of the 150 sewage disposal plants now in operation in this state but one plant has a trained manager who controls the operation of the plant in all of its details and who makes daily chemical and bacterial tests of the effluent from the various units. This plant has long been seriously overloaded, and steps are now under way to construct a more modern and much larger disposal works. In the hands of the ordinary sewage plant attendant the plant in question would long ago have become an unbearable nuisance, and the effluent, discharged into the stream, would undoubtedly have been unsatisfactory and would have created trouble farther down. Under the care of this manager, however, there has been no complaint of nuisance at any time, and, considering the excessive overload that the plant has to carry, the purification obtained has been surprising. Other municipalities would do well to profit by this example.

The example pertaining to a water purification plant is most interesting indeed. A certain state public utilities commission recently handed down its decision in a water works rate case. The utility is privately owned. The water is filtered and in commenting on the filter plant the commission said: "We believe that the most valuable part of this filtration system is the gray matter of the president of the water company." The commission went on to say, in effect, that when this filter plant was installed, many years ago, it was perhaps the most efficient filtration system then on the market, but science has continually progressed and today this system is not modern in any respect. Nevertheless, and here is the important fact, so wisely is this plant handled that its effluent is at all times entirely satisfactory when measured by the most rigid of modern standards. A greater or a more sincere compliment on a utility manager's ability can scarcely be imagined.

Just as water waste curtailment oftentimes postpones for years the construction of costly new supply works, so the competent operation of water purification and sewage treatment plants will, in many instances, extend the useful life of such plants. The parallel lies in the saving to the utility owner of the interest charges on the new investment for as many years as the useful life of the old plant is extended. The amount of such charges is one measure of the value of competent operation.

CONCERNING SOILS AND THE DISTRIBUTION OF LOADS THROUGH THEM.

There is at present a revival of interest in the study of soils from an engineering standpoint, and there are indications that the next few years will bring forth marked developments in this exceedingly important subject. Although engineers have long felt that their knowledge of soils, in their relation to engineering structures, is largely superficial only a few have made a serious effort to add to our present knowledge. The innumerable combinations in which soils exist, and the uncertain effect of varying percentages of water on their physical characteristics, are factors which make real progress exceedingly difficult. In fact, the very magnitude of the problem emphasizes the need for organized and concerted action on the part of many if definite progress is to be assured. Data have been published from time to time on the results of isolated tests of the bearing power and other properties of soils, but in most cases complete data were not given and the benefits which might have resulted from such tests have thus been lost.

In general, progress may be expected in two directions: through a comprehensive study of soils looking toward their complete classification; and through laboratory and field tests to determine load distribution. The appointment, some time ago, of a committee by the American Society of Civil Engineers whose object is "to codify present practice on the bearing value of soils for foundations, and to report upon the physical characteristics of soils in their relation to engineering structures" promises definite results in soil classification. It is hoped that engineers will co-operate with this committee to the fullest extent possible by furnishing to it all available data. (The form in which information is requested was noted in our May 26, 1915, issue). The interest shown recently by those connected with testing stations in various parts of the country gives promise of progress as the result of carefully planned tests and investigations. Preliminary tests have in general been made with dry sand, as this material offers fewest difficulties in testing. A number of tests have been planned, however, in which various kinds of soils will be used.

In this issue we are publishing an interesting series of preliminary tests, the object of which is to determine the vertical distribution of loads through sand. Although these tests are by no means conclusive they do indicate the manner in which vertical loads are distributed through dry sand. An interesting feature of the tests is the photographic record indicating the direction of distribution of the applied loads. This record includes loads applied as a single concentration, as two concentrations spaced at varying distances, and as three concentrations. It is the intention to extend these tests to include various kinds of soil as a part of a comprehensive study to determine the distribution of loads through railway roadbeds.

ENGINEERING POPULARIZED BY MODERN TOYS.

Engineers have said much in recent years about popularizing engineering. It has been asserted that knowledge of the engineer's works must precede popular appreciation of his worth. The truth of this assertion is admitted, and because of the fact it is gratifying to note a small but important agency which is doing much to awaken popular interest in engineering works, namely, modern toys. We were especially impressed on this point by a visit to the toy department of a Chicago store during the recent holiday season.

A generation ago about the only mechanical toy within reach of the average boy, in the rural districts at least, was a small steam engine equipped with a boiler and alcohol lamp. These little contraptions were not over-reliable in operation, even when the hired man understood the deadly nature of the alcohol used. Today there is an amazing variety of mechanically and electrically driven toys. They are substantially made and last long enough to make a permanent impression on the minds of their small owners.

Especially noteworthy are the achievements of the toy makers in perfecting miniature parts of engineering structures with which the child can build bridges, derricks, cranes, elevators, monoplanes, aeroscopes, steam shovels, pile drivers, railroad trestles, railroad signals, skeleton building constructions, etc. In one such line of structural parts the sections are made of cold rolled steel, with round edges, ⅜ in. wide and 1-16 in. thick, with a finish resembling real structural steel. This system of parts at once gives pleasure as a toy and provides elemental instruction in structural engineering. Of course there is a book with each set of shapes to show the child the different structures and machines which can be assembled with them. These pictures are correctly labeled with their technical names. Thus there are shown assembled views of a miniature wind mill, railroad signal, tower derrick, through railroad bridge, jib crane, post crane, lift bridge, deck bridge, high level foot bridge, pile driver, arch bridge, overhead electric wire repair wagon, top braced jib crane, bucket elevator, monoplane, aeroscope, titan crane, signal bridge, swing bridge, aerial railway, inclined tip bucket conveyor, harbor crane, five-story elevator, tower derrick, revolving steam shovel, locomotive crane, portal crane, dock crane, overhead traveling crane, inverted post crane, suspension bridge, transporter bridge, sight seeing tower, elevated railroad with station, and a coal tipple.

This line of toys is suitable for boys from as young as six to as old as fifteen. Not only are the boys instructed by the use of such toys but it is not conceivable that the other members of the household could see all this construction work going on in the house without acquiring rather a lively interest in the works of the engineer.

Mention should be made of the fact that the use of these toys was being demonstrated in several down-town stores of Chicago during the holidays. Of course the same thing was doubtless done in numerous cities throughout the country. The demonstrators really delivered very fair engineering lectures which were listened to, or at least overheard, by tens of thousands of people daily.

It would be possible, if one were so minded, to criticise these toys from the standpoint of the trained engineer. For instance one truss shown in the book is made up of an assemblage of quadrilaterals while, we believe, the triangle is the regulation truss element. But such criticism is uncalled for and is quite beside the point. The toys serve their purpose and they, and similar modern toys, also serve incidentally the very good purpose of popularizing engineering.

THE THREE-VOLUME TREATISE.

In our book review section there are noted this week three books which in the manner of their publication mark a departure in engineering book publishing. These books are the three-volume treatise of Metcalf and Eddy in American Sewerage Practice; the three-volume treatise of Etchaverry on Irrigation Practice and Engineering, and the four-volume treatise by Hood on Reinforced Concrete. Occasional previous examples of engineering books in more that one volume are easily remembered. In earlier days of engineering book making they were more common than afterwards. However, for a score of years, until recently, practice in engineering book publishing has quite persistently followed a standard of adherence to single volume books. It mattered little how great was the quantity of matter it was put within one binding. Prevailing bulkiness was the result.

There is a party among engineers which holds strongly that the monograph, the book in which only one subject is discussed, is the perfect product in engineering publications. While confessing considerable sympathy with this sentiment, we believe that there is a place for the treatise —the comprehensive review and discussion of a group of subjects comprised in a broad branch of engineering. Such books are needed in the teaching of engineering. They are the monuments of broad scholarship in engineering. Their reading leads to broader scholarship in engineering. A profession wants its manuals and its monographs but it also wants its treatises.

The engineering treatise is, because of its justification, with engineers to remain and a manner of publishing it must be had. The older manner, as has been noted, was the bulky single volume. The new manner, as indicated by the treatises whose names have been given, is division into several separate volumes. The new manner has advantages for the reader. It gives him book units more convenient to use. It permits him to distribute his expenditure over a period of time. It permits him to secure any separate volume needed at an immediate expenditure confined more closely to his needs.

EXPERIMENTS ON THE DISTRIBUTION OF VERTICAL PRESSURE THROUGH SAND.

Contributed by Melvin L. Enger, Assistant Professor of Mechanics and Hydraulics, University of Illinois.

It is the purpose of this article to describe briefly some experimental work to determine the distribution of vertical pressure as it is transmitted through sand. This work was carried on at the University of Illinois as thesis work by K. A. Burnell, 1910; W. C. Eells and J. VanDervoort, 1911; L. N. Fisher and H. F. Wagner, 1912; and A. W. Kimbell and M. C. Taylor, 1913. The results obtained are of interest, and the experience gained has also been helpful in planning the more elaborate experiments being carried on at the University of Illinois by the Joint Committee on Stresses in Railroad Track, of which Professor A. N. Talbot is chairman.

Apparatus Used.—Figure 1 is a sectional view of the apparatus used in most of the tests. A concrete slab, 9 x 8½ ft. x 16 in., was used to support the sand. A rectangular opening 6 x 6 in. extends horizontally into the slab about 3 ft. 8 in. from one side. A short vertical opening having an internal diameter of 4⅛ in. connects with the horizontal opening about 3 ft. from the edge of the slab. A 4-in. wooden plug, or plunger, having its upper surface flush with the top of the slab fits loosely in the vertical opening and rests on a knife-edge on a 3-in. I-beam in the horizontal opening. The I-beam acts as a lever in transmitting the load to a platform scale. The ratio of the load weighed on the scales to the load on the plug is as 1:8.09. In some of the experiments the vertical pressure transmitted through the sand was measured by means of the water pressure under a 6-in. diaphragm, which was placed flush with the surface of the slab. A flange with a beveled edge was screwed to the top of a 6-in. pipe, and a diaphragm of packing rubber was clamped over the beveled edge by means of a beveled collar. The 6-in. pipe was connected to a pressure gage by means of a short ¾-in. pipe line. The loading device of the apparatus was movable, and to get pressures away from the axis of the applied load the loading device was shifted to any desired position. In the apparatus used in the earlier experiments the sand rested on a plank floor laid on closely spaced I-beams, but the results were not entirely satisfactory. It is thought that the yielding of the floor had a considerable effect upon the distribution of the pressure.

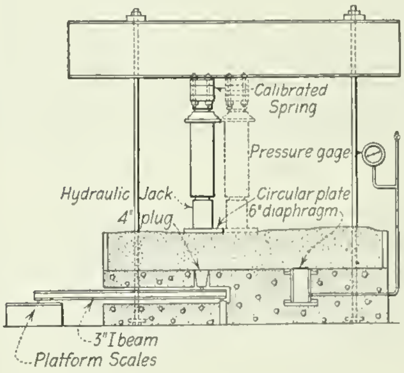


Fig.1

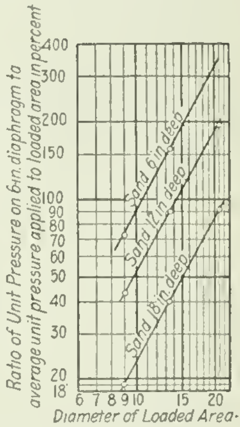


Fig.2

Fig. 1—Sectional View of Apparatus Used in Making Tests to Determine Vertical Pressure Through Sand. Fig. 2—Diagram Showing Relation Between Diameter of Loaded Area and Load Transmitted to 6-In. Diaphragm.

In most of the experiments the load was applied to the sand through a circular plate 13.5 in. in diameter. Circular plates 9 in. and 21 in. in diameter were also used. The load was applied by means of a hydraulic jack which reacted against a 20-in. I-beam connected with the slab by means of four 1-in. steel rods. The load was weighed with a calibrated steel spring whose deflection was indicated on an Ames dial gage.

Scope of Experiments and Procedure.—Experiments were made with depths of sand of 6, 12, and 18 in. Pressures were determined with the center of the load on the vertical axis of the plug (or diaphragm) and with horizontal distances of 3, 6, 12, and 18 in. between them.

For any test the sand was thoroughly compacted before taking readings. For example, when experiments were being made on a depth of sand of 12 in., the plate was started on a layer of sand about 15 in. deep and was forced down to the 12-in. depth. The load was then released and applied several times, and readings were taken of the applied load and of the load transmitted to the plug.

To determine the effect of the size of the area loaded upon the way the pressure is transmitted through the sand, the load was applied to plates 9 in., 13.5 in., and 21 in. in diameter and was measured with the 6-in. diaphragm. In these experiments the center of the diaphragm was directly below the center of the plate to which load was applied.

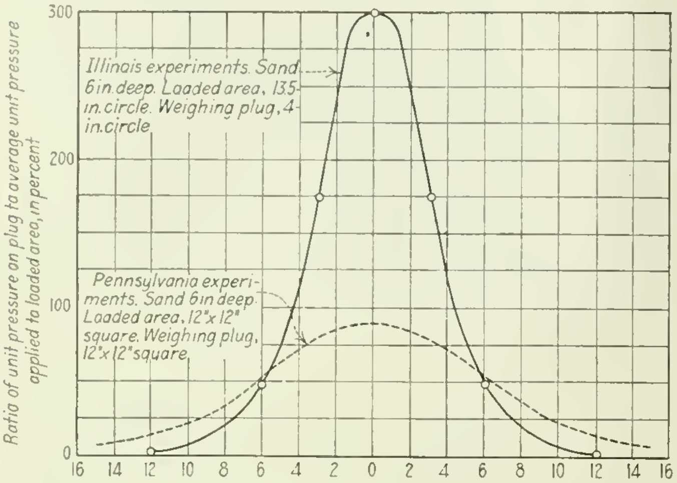


Fig 3

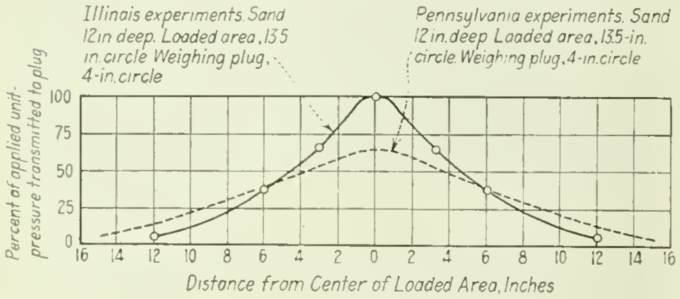


Fig.4

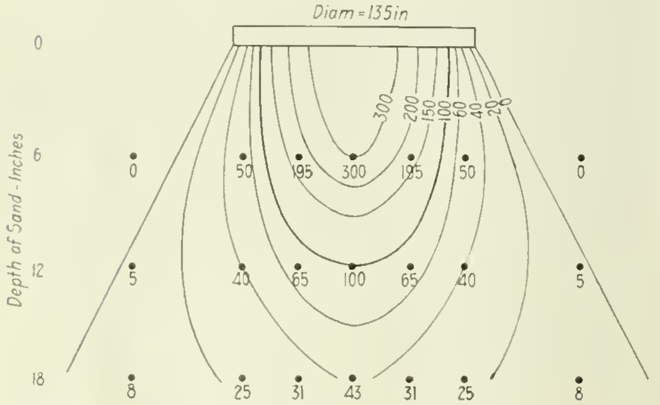


Fig.5

Figs. 3 and 4—Curves Showing Intensity of Transmitted Pressures at Different Distances from Center Line of Load in Terms of Applied Unit Load from Experiments in Which Transmitted Pressure was Measured by 4-In. Plug; Fig. 3 for 6-In. Depth of Sand, and Fig. 4 for 12-In. Depth. Fig. 5—Lines of Equal Vertical Unit Pressure Expressed as Per Cent Which Average Vertical Unit Pressure on 4-In. Plug Is of Average Unit Pressure Applied to Loaded Area.

Results of Experiments and Discussion.—The results of these tests are summarized herewith; in the summary the values given are the percentages of the average unit pressure applied to circular areas of various diameters transmitted to a 6-in. diaphragm through various thicknesses of sand:

Depth of of sand, inches.	Diameters of circular areas, inches					
	9		13.5		21	
	Range, per cent.	Average, per cent.	Range. per cent.	Average, per cent.	Range, per cent.	Average, per cent.
6	70-75	72	140-200	160	....	...
12	36-50	43	87-95	90	189-200	195
18	17-21	19	35-54	40	90-94	92

It will be noted that the size of the loaded area has an important effect upon the proportion of the applied average unit pressure transmitted through sand of a given depth to the diaphragm. In these tests the 21-in. plate carried loads up to 18,000 lb., the 13.5-in. plate loads up to 9,000 lb., and the 9-in. plate loads up to 2,500 lb.

In Fig. 2 the average values of the ratio of the unit pressure on the 6-in. diaphragm to the average unit pressure applied to the loaded area are plotted as ordinates and the diameter of the loaded area as abscissas, using logarithmic scales. It will be noted that parallel straight lines pass through the points which are plotted for each given depth of sand. From the slope of the lines it is found that the proportion of the applied average unit load which is transmitted through sand of a given depth to a diaphragm directly below varies as the 1.86 power of the diameter of the loaded area. It follows, for example, that if a load is applied to a plate 9 in. in diameter such that the intensity of pressure on a small area at a certain distance directly below the center of the plate is 10 lb. per square inch, then the intensity of pressure on the same small area due to the same total load applied to a plate 21 in. in diameter would be 8.9 lb. per square inch. In other words, by increasing the load-carrying area 5.44 times, the intensity of the pressure in the sand directly below the plate at a given depth has been decreased but little, a conclusion very different from the usual assumptions.

No experiments were made by the plug method to determine the effect of the diameter of the loaded area on the intensity of the vertical pressure at any given depth. According to the plug experiments made with the 13.5-in. plate the ratio which the intensity of pressure directly below the center of the loaded area bears to the applied average unit load varies inversely as the 1.95 power of the depth of the sand above the plug. Assuming that this relation holds for other diameters of loaded area, and combining this result with the effect of the variation in diameter previously described, the following equation was found:

$$p = 91 \frac{d^{1.86}}{h^{1.95}}$$

in which p is the ratio, expressed as a percentage, which the intensity of the transmitted pressure at a point h in. directly below the center of the loaded area bears to the average applied unit load, and d is the diameter of the plate in inches. The equation represents roughly the results of the experiments, but it is not probable that it has general application.

In the experimental work the diaphragm has been found to be a less satisfactory method for measuring the transmitted pressures than the method of weighing the load on the plug. The reason is that the diaphragm becomes distorted when load is applied, the center being depressed and the outside portion raised by the water pressure, the distortion increasing with a repetition of the load. For off-center loadings the depression occurs in the part of the diaphragm nearest to the center line of the applied load, while the part farthest away is forced up. So much trouble was experienced with the bursting of the diaphragm that it could not be used for off-center loads on thin layers of sand.

In Figs. 3 and 4 there have been plotted curves showing the intensity of the transmitted pressure at different distances from the center line of the applied load, in terms of the applied average unit load as determined by experiments in which the transmitted pressure was measured by the 4-in. plug; Fig. 3 is for a depth of sand of 6 in. and Fig. 4 for a depth of 12 in. The curves are of interest in showing the lateral distribution of pressure over a horizontal plane at a given depth. Dotted lines, giving the results of experiments made at Pennsylvania State College and reported by J. A. Moyer, are also plotted in

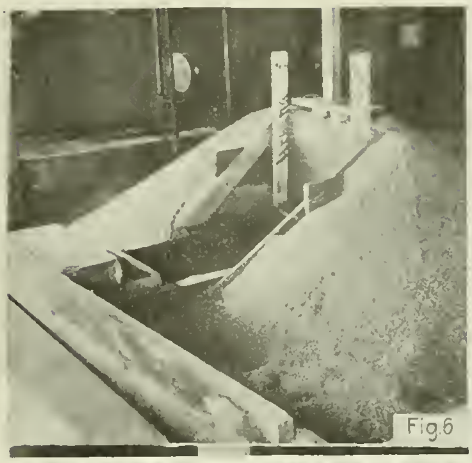


Fig.6

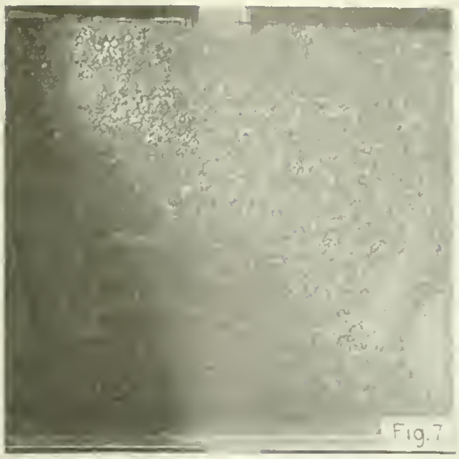


Fig.7

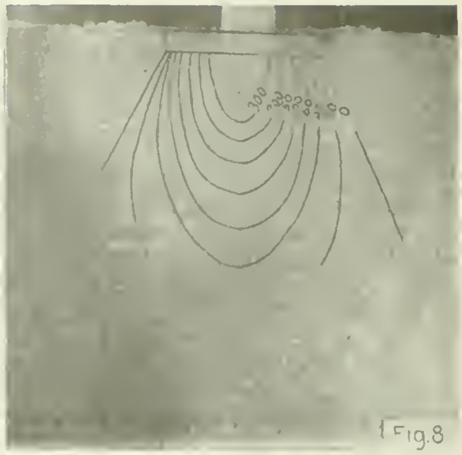


Fig.8

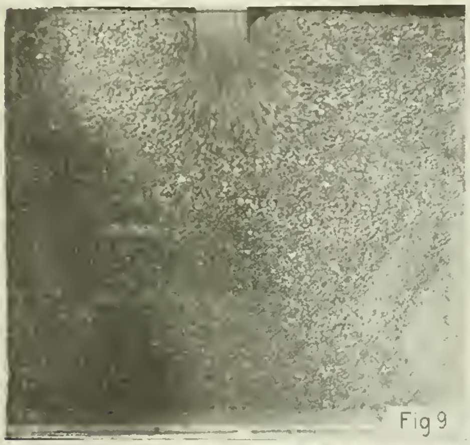


Fig.9

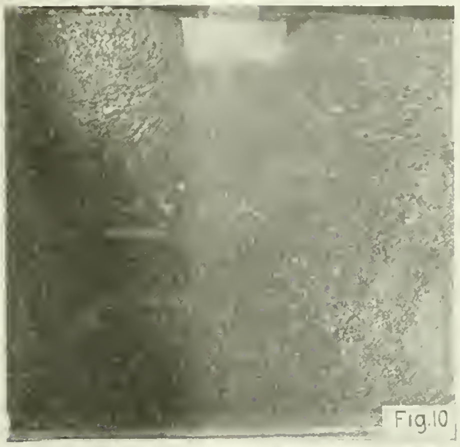


Fig.10

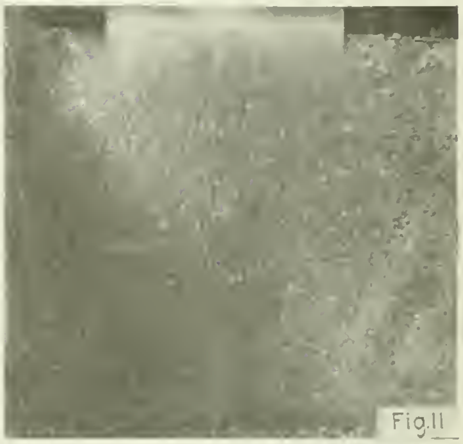


Fig.11

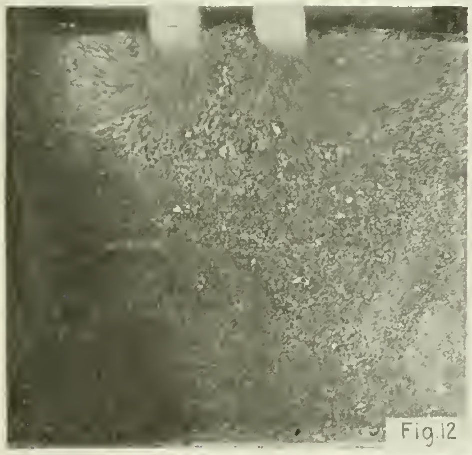


Fig.12

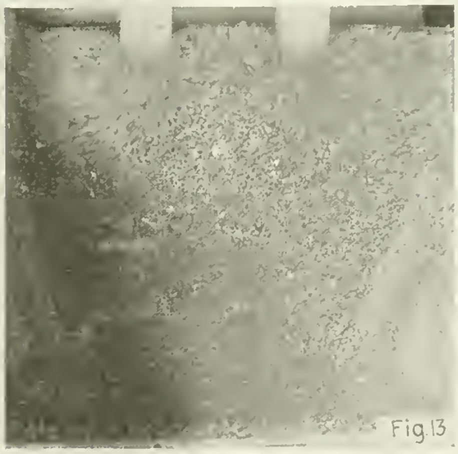


Fig.13

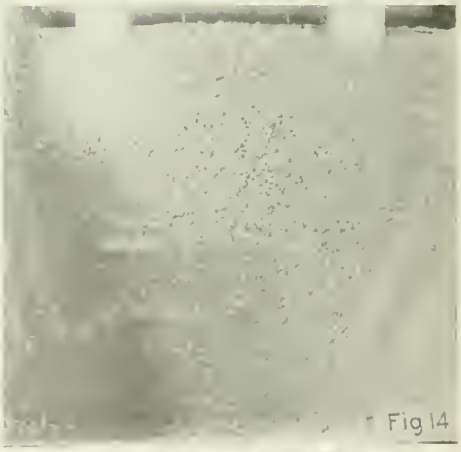


Fig.14

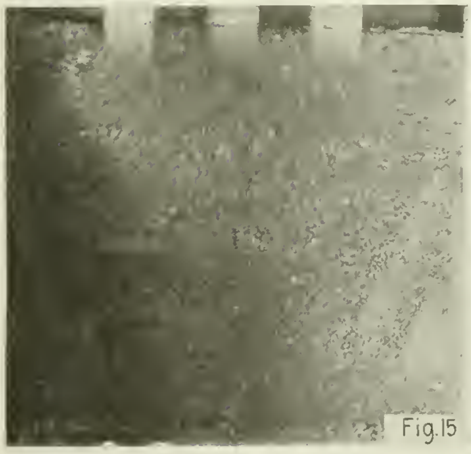


Fig.15

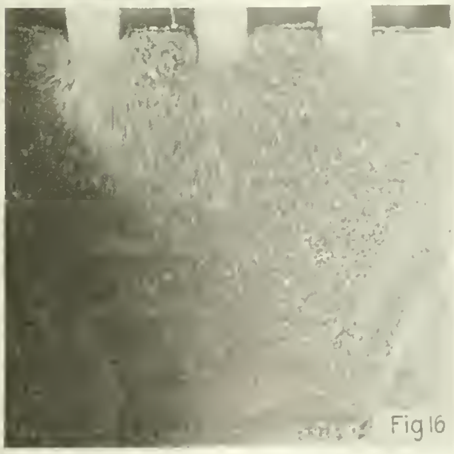


Fig.16

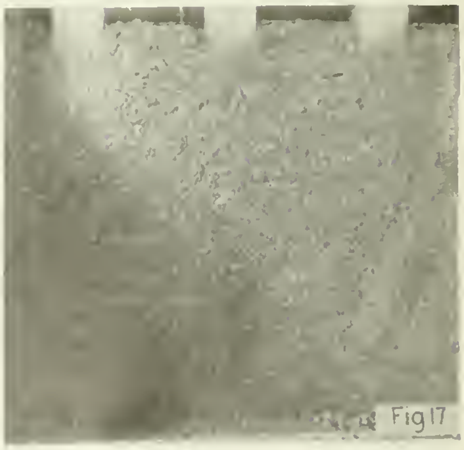


Fig.17

FIGS. 6-17—ARRANGEMENT FOR MAKING SAND-MOVEMENT PHOTOGRAPHS AND PHOTOGRAPHIC RECORD OF EXPERIMENTS.

Fig. 6—Arrangement for Making Sand-Movement Photographs. Fig. 7—Sand Before Application of Load. Fig. 8—Lines of Equal Vertical Pressure from Fig. 5 Plotted on Photograph Showing Movement of Sand Under Block 8 In. Wide. Figs. 9, 10 and 11—Photographs Showing Direction of Movement of Sand Under Action of Single Load: Fig. 9, 2-In. Block; Fig. 10, 4-In. Block; Fig. 11, 10-In. Block. Figs. 12, 13 and 14—Direction of Movements of Sand Under Action of Two Loads: Fig. 12, 2-In. Blocks, 4 In. on Centers; Fig. 13, 2-In. Blocks, 6 In. on Centers; Fig. 14, 2-In. Blocks, 12 In. on Centers. Figs. 15, 16 and 17—Direction of Movement of Sand Under Action of Three Loads: Fig. 15, 2-In. Blocks, 4 In. on Centers; Fig. 16, 2-In. Blocks, 5 In. on Centers; Fig. 17, 2-In. Blocks, 6 In. on Centers.

Figs. 3 and 4. In the Pennsylvania experiments the load was applied to an area of 12 x 12 in., and the pressure was measured on a plug of the same size. The measured pressure was therefore the average over a relatively large portion of the base. The Illinois and Pennsylvania experiments have one inconsistency in common, namely, the sum of the upward pressures under a 6-in. layer of sand exceeds the sum of the applied load and the weight of the sand. The reason in the case of the Illinois experiments is that center loadings were taken first, leaving a pillar of compacted sand above the plug which carried more than average pressures to the plug for the off-center loadings which followed. For depths greater than 6 in. the effect of the compacting was not as great. It is probable, therefore, that the readings at 3 in. and 6 in. from the center are too high for the 6-in. depth of sand.

In Fig. 5 the results of the experiments are plotted to show lines of equal vertical pressure in the sand below the plate. The line of zero vertical pressure has been drawn downward on a 1:2 slope, and an inspection of the experimental results indicate that the vertical pressure outside of this line must be very small. It will be noticed that the region below the center of the load is one of high pressure —a fact of importance which seems generally to have been overlooked. The diagram is instructive in showing the manner of the distribution of the vertical pressure at different depths and at different distances from the axis of the load. It is seen that the pressure on any horizontal plane is far from uniform.

Photographic Record of Experiments.—A number of photographs, which show the direction of the movement of the sand under the action of a load were taken by Fisher and Wagner. Some of these views are shown in Figs. 7 to 17, inclusive. The arrangement used for this purpose is shown in Fig. 6. Sand was piled against a sheet of plate glass, and the camera was placed about 3 ft. from the glass, on the block shown in Fig. 6. Time exposures of from 60 to 90 seconds duration were taken while the blocks were forced slowly and uniformly into the sand. As the sand moved, elongated images of the grains were formed on the photographic plate. The lines formed in this manner therefore show the direction of the movement of the sand for various conditions of loading.

In Fig. 8 the lines of equal vertical pressure of Fig. 5 have been plotted on the photograph.

Figures 12 to 17 are suggestive in showing the manner in which the pressure in the ballast under a railroad tie is affected by the loading and spacing of the adjacent ties tending to restrain the horizontal movement of the ballast. It is evident from Fig. 5 that the pressure in the ballast will not approach uniformity until a considerable depth is attained.

The tests and the photographs suggest that the transmission and distribution of pressure downward through earth and ballast is different from the assumptions frequently made.

USE OF WATER-GAS TAR AND COAL TAR ON CONCRETE SUBJECTED TO HIGH VELOCITIES OF WATER.*

By Charles H. Paul, Construction Engineer, U. S. Reclamation Service.

The regulating outlets through the Arrowrock Dam are molded in 1:2 Portland cement mortar, except for the 28 ft. next the upstream face of the dam, which is lined with semisteel pipe. These outlets are 4 ft. 4 in. in diameter and are subjected to velocities of 60 ft. per second or higher. Wood pipe staves were used for lagging the forms, and great care was used to secure a smooth and straight surface. The upper outlets are 70 ft. in length and the lower ones 130 ft. long. After the removal of the forms they were trimmed, scraped, and washed with grout in the usual way, and then they were painted with two coats of water-gas tar and two coats of coal tar—the same combination that has been used for several years for painting metal that is to be subjected to the action of water.

The idea at Arrowrock was not so much that of waterproofing as to fill all the minute voids in the surface of the outlets, so as to prevent, if possible, the erosion caused by the formation of vacuum in small voids or pockets. Preliminary experiments had indicated that the water-gas tar would penetrate the concrete, and that the coal tar would follow it in and bind to the concrete much better than if it were applied direct, thereby completely filling the voids at and near the surface and coating the concrete with a slick and fairly durable finish, cheap and easily applied.

This coating was applied to all outlets during the fall of 1914. Five of the lower outlets, and six of the upper outlets were in service during the irrigation season of 1915, some of them working for 4½ months under heads varying up to a maximum of 100 ft., with corresponding velocities up to 64 ft. per second.

All of them passed through a fairly normal winter and summer. The one that was used most was operated nearly all the time with its valve only partly open, which is a less favorable condition than with the valve wide open. After this service, careful inspection was made and the tar coating was found to be in excellent condition. In a few small spots the outer coating had come off, but even there the concrete surface was well filled with the tar and was still well protected, apparently, against water action. It is the opinion of the men familiar with all conditions that the use of this tar coating gave thoroughly satisfactory results.

In obtaining material for work of this kind it is very important that the water-gas tar be of very thin consistency. The manufacturers can supply it that way if it is made plain to them that this thin consistency is important, otherwise it is likely to come too thick. The manufacturers can also supply an oil for thinning this water-gas tar, and it is advisable to have some of this oil on the job in case it is needed, but it is believed that the success of the whole operation depends upon the very thin, water-like consistency of the water-gas tar. Both the water-gas tar and the coal tar should be refined.

It is necessary to have the concrete thoroughly dry at the time the first coat is applied. The water-gas tar may be applied without heating, and the second coat may follow the first immediately. The first coat of coal tar may be applied as soon as the water-gas tar has soaked in a little, but the second coat of coal tar should not be applied until after the first coat has set. Both coats of coal tar should be applied hot and brushed out as thin as possible, as a thick coating is much more likely to peel and run.

The approximate cost of painting 1,000 sq. ft. of surface in a 52-in. diameter outlet with two coats of water-gas and two of coal tar as described herein was as follows:

Labor, 4½ days, at $2.50	$11.25
Material:	
12 gallons water-gas tar, at 16 cents	1.92
15 gallons coal tar, at 16 cents	2.40
Brushes and miscellaneous	1.43
Total	$17.00
Cost per square foot, say, 1¾ ct.	

The refined water-gas tar and refined coal tar were purchased from Barret Manufacturing Co. at $4 per barrel of 50 gal. f. o. b. Chicago. Freight to Boise was about $4 per barrel.

---

*Reprinted from the "Reclamation Record" for January, 1916

METHODS EMPLOYED IN GRUBBING THE KENSICO RESERVOIR OF THE CATSKILL WATER SUPPLY WORKS.*

Early in August, 1914, work was commenced grubbing around the shores of Kensico Reservoir, a part of New York City's new Catskill water supply. The land taken for this reservoir comprises some 4,470 acres, and as the water will cover about 2,218 acres, there will be marginal lands of about 2,252 acres. The contractor is required to clear the site of the reservoir to a line 30 ft. outside of the flow line, which is about 27 miles in length.

Under the specifications, grubbing shall include all designated areas within the 30-ft. margin of the reservoir, the reservoir bottom wherever the depth below the flow line is 35 ft. or less, and other areas wherever ordered. The grubbing consisted of the removal of all stumps and roots larger than 2 in. in diameter to a depth of 6 in. below the surface of the ground, and all holes left after grubbing the margins of the reservoir and its bottom to a depth of 10 ft. below the flow line had to be satisfactorily refilled. The areas paid for were the designated areas grubbed, except that no area could be estimated for payment as having a less area than 1,000 square feet, or a less width than 20 feet.

---

*Paper by George A. Winsor before New England Water Works Association as published in the Journal of the Association for December, 1915.

All areas to be grubbed were designated on the ground by actually staking them out in advance of the work as follows: The limit of clearing was staked by measuring 30 ft. horizontally above the flow line at elevation 355; then the elevation 320 contour 35 ft. below the flow line was staked, and with these lines marked on the ground the field party was able to locate most areas with a tape only so they could be platted in the field on the topographic plans, 100 ft. to the inch scale, with the additional information already on these plans, such as boundary walls, highways, building foundations, fences, water courses, etc.; if there were no natural features which could be identified in the maps, the area was located by stadia and subsequently plotted.

The principal natural timber growths around the basin consist of oak, maple, whitewood, birch, hickory, elm, locust, ash, dogwood, cedar, chestnut, and many fruit trees of different kinds. The chestnuts had been killed by the "bark disease."

Most of the clearing on the areas to be grubbed was done during the years 1910 and 1911, and the stumps of the trees were cut off close to the ground; for this reason the old method of pulling the stumps with a stump puller of capstan type, pulling the stump with the tree as a lever, using a block and fall, or the use of the caterpillar traction engine as used at Ashokan Reservoir, were not adapted to the work here.

The grubbing was sublet by the reservoir contractor, and a portion of it was again sublet. The method employed by the subcontractors was as follows: All small stumps from 2 in. to about 5 in. in diameter were grubbed by hand, using axes and mattocks, and all sprouts were cut off of the larger stumps, which were then removed with the aid of an explosive. Sixty per cent dynamite was used most of the time, the quantity depending upon the size of the stump, variety of tree, and the quality of soil around the roots.

Many areas covered with a thick growth of small locusts were encountered; these were pulled with a pair of horses or yoke of oxen with a chain hitched around the tree; usually a little grubbing was done on one side only. This proved to be a very effective and rapid method for removing this species of trees when not too large.

The contractor usually worked about three weeks after a monthly estimate on the grubbing and blasting, as he found it required the remainder of the month to clean up and burn the brush and stumps before his next succeeding monthly estimate.

Work was carried on through the winter months with very little interruption, it being a very mild winter with but little snow; during the spring months, which were very dry, the contractor was forbidden building fires because of the fire hazard to city property adjacent to the clearing limits. He continued with the grubbing operations and burned the stumps later when the grass was green and the weather suitable.

The grubbing was practically completed in August, 1915, thus requiring 13 working months to grub a total of 502 acres. The maximum amount grubbed in a month was 70 acres, in the month of June, 1915, the average amount grubbed per month was 39 acres, but the quantity of labor varied during the progress of the work.

A daily record was kept of the dynamite used by the contractors for the estimate months, and the quantities used per acre have been computed and may be of interest:

Maximum dynamite used, September, 1914	170 lb. per acre
Minimum dynamite used, January, 1915	44 lb. per acre
Average dynamite used, for entire work	95 lb. per acre

The largest timber growth in the basin was grubbed during the month of September, 1914, as indicated by the quantity of explosive used, while during the month of January, 1915, small stumps were grubbed.

It was further demonstrated that it required less explosive to shatter a stump when the ground was frozen than when there was no frost. In the former case very little earth was disturbed by the blast, while in the latter case a large hole was made. A hole was made in the ground with an iron bar, and the explosive was placed under the stump; fuse exploders were always used.

The contract price for grubbing, which included refilling holes, disposing of stumps and brush, and all expenses incidental to the work, was $100 per acre.

In conclusion, the writer believes that the method employed in doing this work was the most economical and the best, under the circumstances. However, had it been possible to do the clearing and grubbing in one operation, the latter would have cost the contractor less, as there would be a considerable saving in both labor and explosive if one of the other mentioned methods had been employed.

A STUDY OF CUSHIONS FOR PAVEMENTS OF THE BLOCK TYPE.*

By Maurice B. Greenough, Instructor in Highway Engineering, Case School of Applied Science, Cleveland, Ohio.

The word cushion is defined by Webster as "anything introduced to relieve the shock or jar between parts." Its use in paving practice represents the application of a word which was originally of popular significance only to a highly specialized engineering function. As used in highway practice then, a cushion is that material introduced between the bottom of the wearing surface and the top of the artificial base in pavements whose surface is of a type represented by wood, asphalt, brick, or stone block.

The nature of the filling material between individual blocks has no bearing upon the use of the term, but serves to accentuate some of the properties ascribed to the cushion.

According to the definition and to accepted practice, the primary function of the cushion in pavements of the block type is to relieve the shock of moving loads on the surface of the pavement. Other functions may be attributed to the cushion: to provide a firm and uniform support for individual blocks; to compensate for irregularities in the surface of either the base or the blocks composing the surface, and, finally, to transmit the effects of surface loads to the artificial base with a uniform distribution of intensity.

A variety of materials have been used for cushions at one time or another, but sand alone or in combination with other materials has enjoyed the widest application for this purpose. Local availability of stone dust or granulated slag has determined their use in a number of instances, but stone dust is similar to sand in its physical characteristics and properties and granulated slag may approach a condition similar to that obtained by the use of cement in the cushion. Bituminous materials have been used to some extent, particularly in wood block construction, but more for the purpose of waterproofing the bottoms of the blocks than for providing an elastic cushion.

Wood block pavements have been laid upon a sand cushion for many years, but within the last decade a mixture of sand and cement has superseded plain sand to a large extent. Asphalt blocks have been laid upon a sand and cement cushion through the necessity of providing a firm and uniform support for blocks having so large an exposed area in proportion to the depth.

Up to 1913 sand was almost universally used as the cushion material for both brick and stone block pavements, and it is only since that time that sand-cement mixtures have been employed to any great extent, and in some cases that it has been dispensed with entirely.

During the time that cushions have been in use there have been two important and indicative tendencies developing that are worthy of attention. They are: (1) The increasing emphasis laid upon the necessity of securing a uniformly dense degree of compactness. (2) The gradual reduction of cushion thickness.

The origin of both these tendencies lies in a desire to obtain greater intimacy between individual grains in the cushion and between the surface and base of the pavement as a whole.

An unconfined mass of sand cannot be said to possess elasticity, the property which must be developed to make a satisfactory cushion. The minimum elasticity of sand exists when a multitude of particles are in the free state and the maximum obtains when those particles are bonded in the form of sandstone or even pure quartz. Therefore we may say that the degree of elasticity that can be developed by sand is directly proportional to the intimacy of contact between individual grains or to the extent of its confinement. It is true that each grain may possess elasticity, but it may be overshadowed and rendered unavailable by the lack of intimate contact.

---

*Presented before Section D of the American Association for the Advancement of Science at the Columbus Meeting, Dec. 29, 1915.

We may say then, that a sand to be suitable for use in pavement cushions should have a uniform grading of particles from the finest to the coarsest, providing the finest sizes are not composed of materials whose nature or composition may be altered by contact with moisture.

Most specifications for sand cushions seek to secure maximum density by laying stress upon spreading and rolling irrespective of any consideration as to the possibility of ever producing a dense cushion with any amount of rolling in view of the granulometric composition of the sand. The following quotation illustrates the point:

> Upon the foundation as specified will be laid a bed of clean, dry sand, to bring the surface of the pavement when thoroughly rammed and rolled, to the proper grade. The sand cushion shall be brought to the exact form and crown by means of a template resting on the curbs or on scantling embedded in the sand. The template shall be drawn forward and backward immediately in front of the brick laying, so that the sand cushion shall be maintained constantly at the proper crown. If there still remains any unevenness in the cushion the same shall be brought to a smooth surface by the aid of a lute. Cushion to be rolled with a hand roller weighing not less than 10 lb. per inch in width. The depth of the sand shall not be less than 1½ in. nor more than 2 in.

Sand has enjoyed its wide use as a cushion material because of its universal availability and consequent low cost, and because under ideal conditions it may satisfy all the functions of a cushion. A study of sand cushion specifications will show, however, that there has been little or no attention paid to the details which might produce ideal conditions in every case, and that the bulk of attention has been devoted to those properties that are common to sand in the generic sense. At no time have specifications been drawn with the care and accuracy that this feature of pavement construction warrants. In some cases, fine material other than that which would alter its composition in the presence of moisture, has been admitted in a conscious effort to increase the probable density of the cushion.

In early practice, cushions for both brick and stone block pavements were as deep as 3 ins. There has been a gradual reduction in depth until now we find most brick pavements laid upon cushions from 1 to 1½ in. deep, and cushions for stone block pavements are usually limited to a maximum of 2 ins. Where sand is still used as the cushion material for wood block pavements, 1 in. is the common depth. One-half an inch is the customary depth for the mortar cushion of wood and asphalt block pavements. Doubtless the reduction in thickness of pavement cushions has been brought about, in part, by smoother surfaced concrete bases.

The intricateness of the cushion problem depends upon the nature of the joint filler in the pavement surface. If the individual blocks composing the surface are free to move without affecting their neighbors, the effect of surface loading is localized to that portion of the cushion underlying each block.

It is only when the blocks in the surface are bonded to form a monolithic slab that the elastic function of the cushion reaches its maximum importance, and it is in this connection that so much discussion has recently arisen.

The time has come when we should look upon a pavement as an engineering structure and approach its problems from the same angle that we approach other engineering problems, namely by methods of exact analysis, based upon the fundamental laws of mechanics. That the problems of pavements are more complex than those of other engineering structures does not prevent the possibilities of an ultimate solution. This complexity of elements has simply inhibited the development of an exact analysis, not prevented it.

The stresses to which pavements are subjected arise from two sources, the loads of traffic and thermal changes. Under the latter may be grouped all the stresses which are due to thermal conditions accentuated by the presence of moisture. Stresses may be set up at any time which arise from a single source or they may be created by combined traffic and thermal forces. An analysis of pavement stresses predicated the fact that a structure is inherently weak whose component parts are not so arranged as to meet stresses from both sources in the most advantageous manner.

For the purpose of analogy a pavement subjected to traffic load may be compared to a loaded arch composed of individual blocks united to act in harmony. In the case of the latter, each unit may be subjected to direct compression or shear, while the arch as a whole may be undergoing bending. So it is with a pavement; we may expect forces of direct compression and shear in the individual blocks as the result of flexure in the surface of the pavement as a whole. If we consider thermal stresses, direct tension may be added to those mentioned.

The illustration may be carried still further by comparing a pavement to an arch composed of metal plates connected by rivets. In this case, the plates are subjected to direct tension, compression, or shear; the rivets are subjected to bending and shear. In this analogy, the grout between individual blocks may be compared to the rivets, whose function it is to transmit the stress from one unit to another. While the rivets may be subjected to a true bending stress in the transmission of stress between plates, the grout between blocks in a pavement does not carry direct bending, since the flexure of a pavement surface produces compression in the joints above the neutral axis and tension below. It is further called upon to resist the impact of moving loads upon each block which introduces the element of shear.

The writer would not have these illustrations construed as a belief that a pavement should be constructed as an arch, he wishes rather, to bring out the similarity of conditions surrounding the individual units of both structures.

An incident came to the attention of the writer recently in which the rear wheels of a loaded truck weighing about 12 tons, proceeding at a rate of about 8 miles an hour, broke through the surface of a 4-in. cement grouted brick pavement laid upon a natural earth foundation, brought about probably by lack of foundation support. The accident served to confirm an opinion that the writer has held for some time that we are working with a very narrow margin of safety in our grouted block pavements as far as shearing resistance is concerned, in view of the fact that we cannot always be sure of adequate support for pavement surfaces.

A series of experiments conducted at Case School of Applied Science by Mr. H. D. Churchill as a thesis in 1915, showed that the ultimate shearing resistance of a 4-in. brick perfectly grouted with a 1:1 mixture of sand and cement is approximately 17,800 lb., an average value of 16 tests. The tests were conducted by grouting the blocks in strips of three, supporting them on the outside blocks, and applying a load at the center of the middle block. An adjustable strap was placed around the three blocks at the lower edge to prevent bending, so that the action on the grouted joints of the middle block was as nearly pure shear as possible. The load was gradually applied. The figure given as the vertical shearing resistance of the joints represents an adjusted value to include the additional resistance that might be expected had the block subjected to loading been grouted on the ends as well as on the sides.

In the case of the truck which I mentioned, we may assume that the load was distributed in the proportion of one-third to the forward axle and two-thirds to the rear axles, making the load upon one rear wheel about 8,000 lb. The tires on the rear wheels of the truck were of the caterpillar type, so that it is reasonable to assume that the load would have been transmitted to individual blocks with impact. The pavement was quite smooth on the surface so that on the principle of mechanics that a suddenly applied load produces double the equivalent of a gradually applied load both in the load itself and in the intensity of the stress developed, the probable load exerted upon the blocks in this pavement was 16,000 lb., as a minimum estimate. The ultimate load of 17,800 lb. was obtained with a perfectly grouted joint, that may or may not have existed in the case under discussion.

The logical conclusion to be drawn from this illustration is that unless the blocks in the surface of a grouted pavement are adequately supported, stresses may be set up in the joints far in excess of the safe limit. If the pavement is constructed with a cushion on an artificial base, it is the function of the cushion to provide such a support and to contribute its elastic resistance, both of which prevent an undue stressing of the joint filler. There is a limit to the elastic deformation that a pavement may undergo and retain its integrity.

The question naturally arises then, "what is the allowable deflection that a pavement surface constructed of the various kinds of blocks may be subjected to, and which may not be exceeded without destroying the property of elastic recovery?"

Unfortunately the answer to this question hinges upon a knowledge of the properties of the several materials, both in themselves and when combined to form a pavement surface, that is at present unavailable. This lack of information, while it may prohibit a quantitative analysis, does not prevent us from making a qualitative analysis, based upon experience with other engineering structures which embody more or less the same elements.

The passage of a vehicle over a pavement produces a deflection in the surface which is distributed over a wide area. In the case of a slab, rectangular in shape, supported and firmly clamped on the four edges, it has been shown that a static load produced deflection over an area 2½ times as long as it is wide, and it is probable that the affected area of a pavement at any given instant has similar proportions. If, with the slab, the edges had not been clamped, the negative bending moment would have caused them to rise over the supports. The continuity of material in the case of the pavement, serves to effect a condition similar to that of clamping the edges of the slab, so that we may expect, when a deflection is produced by a passing load, that there will be, at the limits of the affected area, a tendency for the surface to rise, caused by the negative bending moment introduced. This, of course, represents the simplest case, when only one vehicle is producing deflection at a time; but the effects produced by more than one vehicle perhaps moving in the opposite direction, would be combinations of the effect of one vehicle. For the purpose of our discussion it is sufficient to point out that the elastic properties of the materials involved are being constantly brought into play in a more or less complex manner.

When the surface of a pavement is depressed by loads, the work performed in any given instance is the measure of the resiliency. When the internal stresses created are within the elastic limit of the structure, or within the range through which the deformation has a constant relation to the stress, the amount of the elastic energy stored and recoverable is equal to the resiliency. If, however, the elastic limit of the structure is exceeded, some of the applied energy is dissipated in the form of heat. In the former case, the structure will resume its normal position upon removal of the load, but in the latter there can be no recovery and there exists a permanent deformation.

It must be remembered that in pavements of the block type, with the exception of wood and perhaps asphalt, the materials involved are only slightly elastic, and when combined in the form of a pavement, the elasticity of the structure as a whole depends upon the integrity of bond between the various elements. It is essential that there should be a slight relief for applied loads, in order that the stresses created may build up slowly, otherwise the pavement may be subjected to stresses that are of double intensity due to impact alone, which may be augmented by further impact stresses caused by irregularities in the surface.

We may say then, that to successfully withstand heavy loads, the elastic properties of all the elements of the pavement should be brought into play, and to produce this condition the elements should act in harmony.

In the case of a pavement having a sand cushion, it should be so graded in size of grains and so densely compacted that none of the energy transmitted to it from the surface shall be spent in causing a re-arrangement of the grains. Such energy is lost as far as assisting the surface in its elastic recovery is concerned, and the surface material is overburdened in proportion to its capacity.

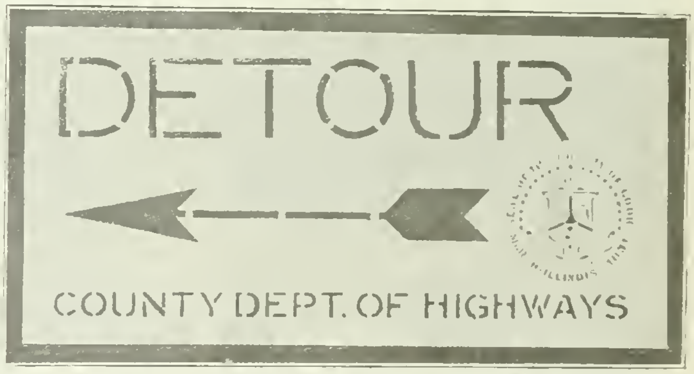
If we assume that a sand cushion fulfills all its functions ideally, not only will it contribute its share of recoverable elastic energy, but it will transmit some of it to the base and it will be brought into play.

Thus we find the introduction of the sand cement-cushion for block pavements to have been caused by a desire to make the cushion such an integral part of the pavement that there should be no chance of losing energy needed to successfully bear heavy moving loads. The presence of the cement assures a cushion of uniform density, and one that can perform all the functions ascribed to cushions in general leaving nothing to chance.

Not only is the cushion inherently stronger, but it stiffens the whole structure by its complete bond to the surface and the base. In such a pavement, the natural relief against suddenly applied loads is found in the subgrade itself, and the possibilities that any one element of the structure will be overburdened are lessened.

A DETOUR SIGN FOR USE ON CLOSED ROADS.

The accompanying illustration is a reproduction of the 18x24-in. detour sign used on Cook County roads closed for any reason by the order of the county superintendent of highways, George A. Quinlan, Chicago. The 6-in. letters and 18-in. arrow are painted in black on a yellow background which makes them easily distinguishable. These signs are placed along the road, not only at barricades, but through the entire detour strip for traffic going in both directions. Road users have merely to follow the signs and turn wherever the arrow indicates.



Detour Sign, Cook County, Illinois.

SOME DATA ON THE OPERATING COST OF OFFICE BUILDINGS.

The following data give some operating costs for office buildings of various sizes, the data being compiled by George W. Martin, of the New York Service Co., which operates numerous power and heating plants in New York City. The data were presented at a meeting of the New York Chapter of the American Society of Heating and Ventilating Engineers.

Contents of building, cu. ft	Operating cost per 1,000 cu. ft.
6,500,000	$1.04
4,700,000	1.32
2,097,800	1.42
2,022,000	1.74
1,600,000	1.75

These values are stated to be fairly comparable, as they include practically the entire cost of operation; they include coal, electric current, cost of ash removal, wages, etc. The fact that the plotting of these costs produces nearly a straight line seems to indicate that they may be used to establish operating costs in other buildings of the same type. The coal used in the buildings listed was No. 3 "buckwheat," costing $2.50 per ton; it was burned under forced draft.

Other data presented by Mr. Martin apply to the coal consumption in an office building for two successive seasons, one season without a steam meter and the other with a steam meter installed. An average outside temperature curve was also included. The coal consumption, without the meter, ranged from 600 tons in January to 300 tons in May and back to 550 tons in December. After the meter was installed the saving in fuel was very noticeable; for example, the coal used in October was 100 tons less than for the same month of the previous year.

Other data presented tend to show the cost, per 1,000 lb. of steam produced, of the different kinds of coal in common use. These data are as follows:

Grade of coal.	Market price net, per ton.	Cost per 1,000 lb. of steam. Test No. 1.	Test No. 2.
No. 3 buckwheat	$2.50	12.61	12.26
Soft and No. 3	3.15	15.6	16.4
No. 2 buckwheat	3.15	19	19.6
No. 1 buckwheat	3.65	19.86	18.25
Pea	4.25-4.50	21.7	20

The above values show the relatively high cost of pea coal, although this grade of coal has the advantage of not requiring such frequent attention to the fire; and this should be taken into consideration in figuring the cost, as its use would show a saving in the firing cost. The values given are based on a forced draft in the ash pit of about ½ in., the firemen being instructed to keep the draft so that a handkerchief held near the draft door would be gently drawn in. In each case the test was conducted for a period of 24 hours.

DESIGN AND CONSTRUCTION OF AN INTERCEPTING DRAIN TO PROTECT THE SURFACE WATER SUPPLY OF FALL RIVER, MASS.*

By H. K. Barrows, Consulting Engineer, 6 Beacon St., Boston, Mass.

The water supply of the city of Fall River is obtained from the North Watuppa Pond, a large natural pond about 1,800 acres in area located just easterly of the city. Water is taken at the west shore of the pond and pumped into four large steel tanks, located at different sites in the city, but having a common elevation of overflow, with a total storage of about 5,000,000 gal. Thence the city is supplied through the usual system of pipe mains.

As the North Watuppa Pond and its drainage cover a large area, it became necessary many years ago to give attention to the pond and its adjacent shores, with a view to maintaining the purity of the water supply. To place this matter under definite control, in 1895 the Reservoir Commission was established, which includes the three water commissioners, the mayor, and the city engineer. Since that time a large portion of the land bordering on the shores of the North Pond has been purchased by the city through the Reservoir Commission, and the improvements in the water supply with respect to its quality and adequacy now going on and projected are under the immediate direction of this commission.

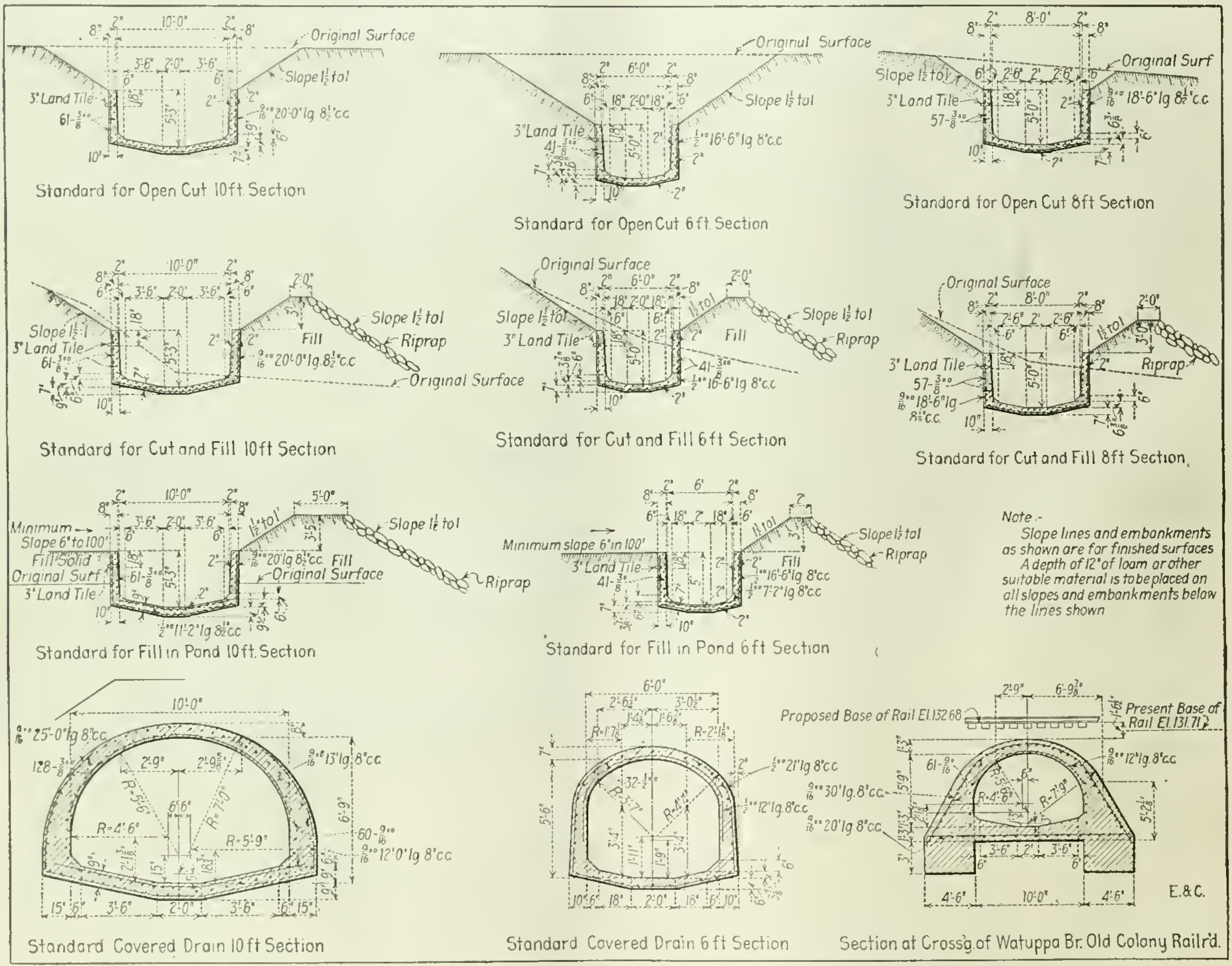

Standard for Open Cut 10ft. Section
Standard for Open Cut 6ft. Section
Standard for Open Cut 8ft Section
Standard for Cut and Fill 10ft Section
Standard for Cut and Fill 6ft Section
Standard for Cut and Fill 8ft Section
Standard for Fill in Pond 10ft. Section
Standard for Fill in Pond 6ft Section
Standard Covered Drain 10ft Section
Standard Covered Drain 6ft Section
Section at Crossg. of Watuppa Br. Old Colony Railr'd.
Original Surface
Slope 1½ to 1
3" Land Tile
Fill
Riprap
Minimum Slope 6" to 100'
Fill Solid
Proposed Base of Rail El. 132.68
Present Base of Rail El. 131.71
Note:- Slope lines and embankments as shown are for finished surfaces. A depth of 12" of loam or other suitable material is to be placed on all slopes and embankments below the lines shown
E.&C.

Fig. 1—Standard Cross-Sections of Reinforced Concrete Intercepting Drain to Protect the Fall River, Mass., Water Supply.

In 1892 an agreement was entered into by the city and the Watuppa Reservoir Co. which has served ever since that time as the basis for use of water by the city. Briefly, it gives the city the opportunity to draw water from the North Pond for purposes of water supply, and only limits the use of water by the Reservoir Co. and mills when the water in the South Pond has reached a certain minimum level.

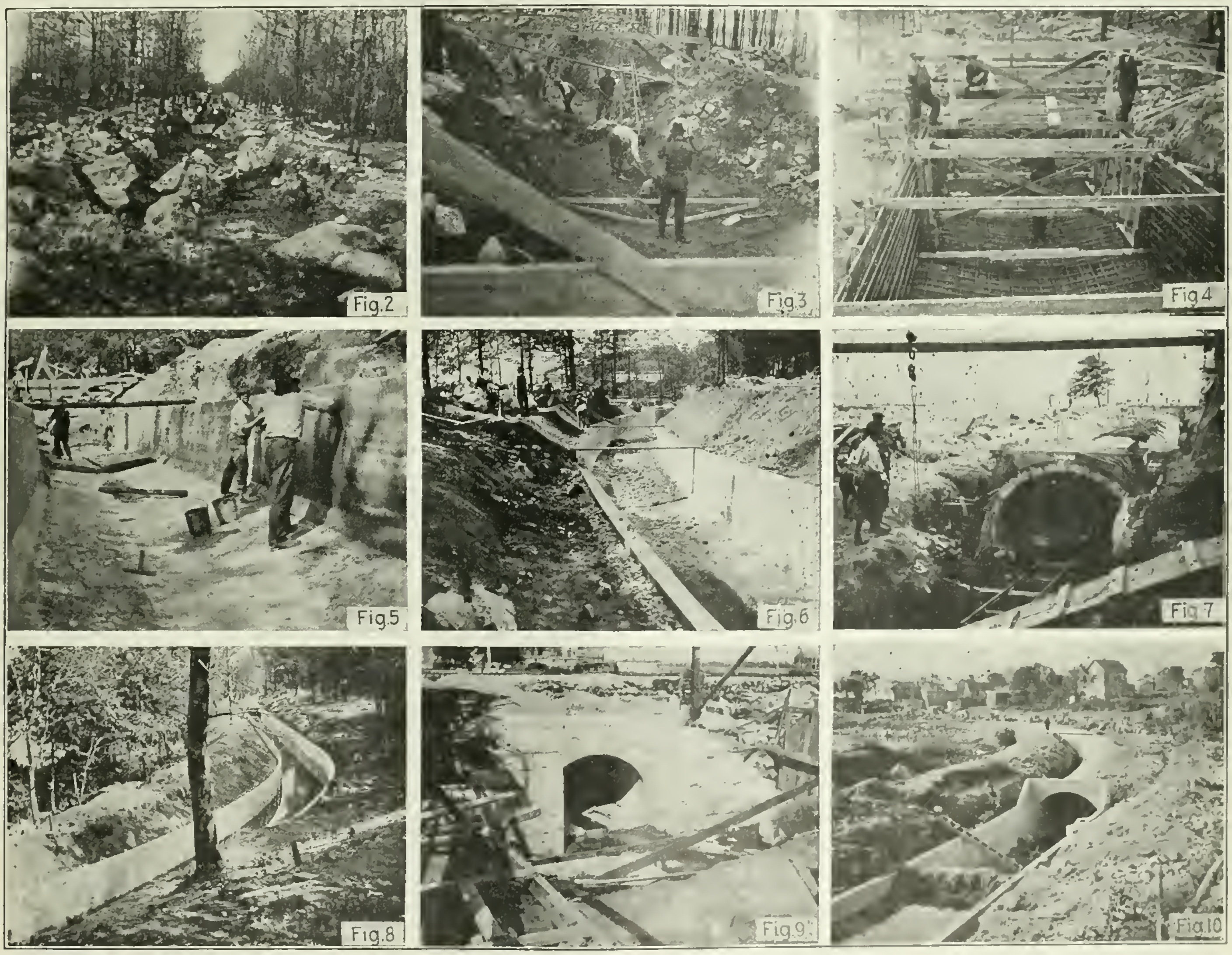
---

*Extracts from a paper before the New England Water Works Association.

On Dec. 6, 1897, the city took by condemnation the entire North Watuppa Pond, including all the islands in the pond and the land under the pond, for the purpose of preserving and protecting the purity of the water supply, without, however, increasing the amount of water to be taken and used by the city except in conformity with the terms of the agreement in 1892 with the Reservoir Co.

Stringent regulations in regard to the protection of the pond for water supply purposes were made by the State Board of Health in 1907, and have been in force since that time.

The legislative act of 1909 authorized the city to borrow money for the construction of works for the protection of its water supply, and it is under this act that the construction of the intercepting drain along the west shore of the pond here described, is now being carried on.



VIEWS OF THE INTERCEPTING DRAIN TO PROTECT THE SURFACE WATER SUPPLY OF FALL RIVER, MASS.

Fig. 2—Typical of General Nature of Ground Traversed by the Drain. Fig. 3—Method of Shaping Sub-grade. Fig. 4—Forms and Reinforcement on 10-ft. Open Section. Fig. 5—Completed 10-ft. Open Section—Removing Forms and Finishing. Fig. 6—Grading Along 10-ft. Open Section. Fig. 7—Ten-foot Covered Section—Gap Left for Removal of Forms. Fig. 8—General View of 10-ft. Open Section—Grading Incomplete. Fig. 9—Granite Ashlar at Outlet. Fig. 10—General View of 10-ft. Open and Covered Sections—Grading Incomplete.

It will be noted that the city has full power to protect its water supply from pollution, but that the use of the water in the North Pond is shared jointly with the Reservoir Co. in accordance with the agreement of 1892, which has been in force since that date. This practically means that the city is entirely at the mercy of the Reservoir Co. in respect to the drawing down of water in the North Pond, so that under present conditions storage of water from year to year for purposes of assuring a sufficient water supply is not possible.

The Reservoir Commission has made steady progress since 1895 in securing land adjacent to the North Pond and constituting its drainage area, and a large proportion of this is now owned by the city.

On the west shore of the pond is a large tract of land to a considerable extent populated, and in some portions thickly populated, which it has been impracticable to obtain by purchase, and, acting under the approval of the State Board of Health, the Reservoir Commission has, under the act of 1909, taken measures to divert directly to the South Pond, by means of an intercepting conduit running close to the west shore of the North Pond, all the drainage on the west shore beginning with Terry Brook, including Highland and Cress brooks and land adjacent to the pond for the remainder of the distance to Pleasant St. near the South Pond.

It is of interest to note that in the first published report of the Water Commissioners, dated January, 1875, they recommended the purchase of a strip of land along the west shore of the North Pond from New Boston Road to the Narrows for the purpose of building a road and constructing an intercepting drain to prevent drainage from populated districts entering the North Pond. This was the first official suggestion in regard to the construction of this intercepting drain, and the contract for its construction was signed on Jan. 28, 1915, almost exactly 40 years from the date when it was first suggested.

The total drainage area tributary to the intercepting drain on the west shore of the North Pond is 2.32 acres. Nearly half of this consists of the drainage area of Highland Brook. Adjacent to the pond, in the general vicinity of County St., is a little over 0.5 square mile of area which in its southerly portion, between County and Pleasant Sts., is thickly populated. Of the total drainage area diverted to the South Pond, probably about one-third is in a closely populated condition. The remainder of the drainage consists of grass and cultivated areas. Within the drainage are also two large cemeteries.

Between Terry Brook and Highland Brook, a distance of about 1,962 ft., the drain consists of a 24-in. vitrified pipe laid on a slope of 0.178 per 100, beginning at a small dam and headworks on Terry Brook at Meridian St. The crest of this dam is at elevation 139.7, and the area flowed at this elevation is about eight acres. The ordinary flow, however, will be taken through a gate at such an elevation that water can be drawn down to about elevation 137.4.

At Highland Brook is a low concrete dam and intake, the crest of the dam being at elevation 139.5. From Highland Brook at Meridian St. to a point near the former channel of Cress Brook, a distance of about 1,500 ft., the drain is of standard 6-ft. open section, with the exception of two short stretches under Meridian St. and at New Boston Road, which are of 6-ft. covered section. This portion of the drain is laid on a slope of 0.0685 per 100. The 24-in. pipe from Terry Brook enters at the side of the 6-ft. open section a short distance below Meridian St.

At Highland Brook intake the ordinary flow will be taken through a gate, the sill of which is at elevation 132.8. At the elevation of the crest of the spillway there will be a flowage of about 43 acres, and it is planned in the future operation of the drain to close this gate when necessary and hold water for short periods of time in the Highland Brook basin, to prevent overtaxing the capacity of the portion of the drain adjacent to the County St. area, which has steep slopes and will in time be closely built up and, therefore, quick spilling in its nature.

It is intended to divert Cress Brook at a point about 1,000 ft. from the pond directly into Highland Brook, so that advantage can be taken of the pondage at Highland Brook. This diverting drain from Cress Brook is a 30-in. pipe laid on a grade of 0.45 per 100 and was constructed by the Reservoir Commission prior to the time of letting the contract for the main drain, although the actual diversion of the brook cannot take place until the main drain is completed.

Below the old channel of Cress Brook the drain is of standard 8-ft. open section laid on a slope of 0.0235 per 100 for a distance of about 2,500 ft. For the remainder of the length (some 8,000 ft.) the drain is of 10-ft. section and for the greater part of open section. A short length under Bedford St., and in the vicinity of the main pumping station is of 10-ft. covered section, as is also a length of about 1,800 ft. in the lower portion of the drain near the South Pond on Pleasant St. The greater portion of the 10-ft. open section is laid on a grade of 0.104 per 100, although between Pleasant St. and the South Pond the slope is considerably steeper—0.28 per 100.

In Table I are summarized data in regard to size, slope, capacity, etc., of the different sections.

TABLE I.—DATA ON SIZE, SLOPE AND CAPACITY OF MAIN INTERCEPTING DRAIN OF FALL RIVER WATER SUPPLY PROTECTION WORKS.

Section.	Length, feet.	Size.	Slope per 100.	Capacity, cu. ft. per sec. (Full.)	Total drainage area, acres.
TerryBrook to Highland Brook	1,962	24-in. pipe	0.178	10	140
Highland Brook to Cress Brook (Sta. 105)	1,576	6-ft. open	0.0685	125	1,120
Sta. 104 to 79	2,500	8-ft. open	0.0235	104	(1,150)
Sta. 78 to 63±	1,500	10-ft. open	0.0235	145	(1,200)
Sta. 63 to 58	500	10-ft covered	(0.0235) (0.104)	(145) (306)	1,240
Sta. 58± to 17±	4,100	10-ft. open	0.104	306	(1,300)
Sta. 17 to 1±	1,800	10-ft. covered	(0.104) (0.280)	(282) (462)	(1,385)

It will be noted that this intercepting drain is of reinforced concrete and consists largely of open section work. This type of drain was decidedly more economical for a given capacity than a covered section. It also materially simplified the matter of the interception of all drainage from the pond and provides a positive cut-off or barrier that will effectively prevent any polluted water from reaching the North Pond.

The details of the various standard sections are shown on Fig. 1. To localize the effect of expansion due to change in temperature, and consequently of cracks in the concrete, a large amount, about ½ of 1 per cent, of steel reinforcement is used longitudinally, and this is placed in two rows of steel, one near each side of the concrete. The invert is of arched form, although this is obtained by means of chords rather than arcs of circles, in order to simplify the concrete work.

Provision for draining the side walls for a distance of 2 ft. from the top of the wall is made by broken stone filling for a width of 8 in. back of the wall. On the side away from the pond, at intervals of 25 ft., 3-in. tile pipe is set in the walls 24 in. below the top, for drainage purposes. On the side next to the pond no tile pipes are placed, but at occasional intervals drainage channels are provided so that water will not accumulate back of the walls near their top and thus cause danger of frost action and possible pushing in of the wall. Several construction views are shown in Figs. 2-10.

Great care is being taken in construction to obtain a dense and impervious concrete. The specifications provide for mixing in proportions "to be exactly determined from time to time by the engineer, in accordance with the relative coarseness of the aggregate"—the average relative proportions being from 1:2:3½ to 1:2½:4. Frequent sieve tests of sand and broken stone are made to help govern the selection of the best proportions. Thus far the prevailing mixture for best results has been closely 1:2:4.

Bids were received on Sept. 4, 1914, ranging in total amount from about $174,000 to about $240,000. Owing to the condition of the bond market last September it was not possible to sell bonds at par, and as this was required under the legislative act, there was a delay in awarding the contract until Jan. 28, 1915, when it was awarded to the lowest bidder, the Hanscom Construction Co. of Boston. They began work as soon as practicable in the spring and at present are making good progress, with more than 50 per cent of the construction completed.

On the easterly side of the North Pond is a very considerable area, portions of which are quite closely populated, which must be diverted directly to the South Pond by an intercepting drain. This includes the drainage areas of the North and South Nat Brooks and of Ralph Brook. Recent analyses made of samples of water at different places on these brooks indicate serious pollution and confirm the urgent necessity of this construction.

The general method of diversion has already been approved by the State Department of Health, the detailed plans for this work are now in process of preparation, and the work will undoubtedly be commenced as soon as practicable.

The total drainage area of the North Pond at present, including the area of the pond itself, is about 11.5 square miles. The intercepting drain on the west shore of the pond will divert directly to the South Pond about 2.3 square miles of drainage. The Nat and Ralph Brook diversion on the east side of the pond will take about 0.7 square mile more. The total area to be diverted is thus about 3 square miles, leaving for water supply purposes about 8.5 square miles of drainage area, of which 2.8 square miles is water area. The capacity of this 8.5 square miles of drainage area of water supply may be roughly estimated in the following manner:

For the average year the precipitation is about 47 in., and from measurements of the yield of the pond made covering two years, it has been found that about 50 per cent of the precipitation is available as yield, the remainder being used up by evaporation, the demands of vegetation, and other losses. On this basis the total amount of water available for the average year would be about 3,460 million gallons. In a dry year like 1910, when the precipitation was about 34 in., probably not over 40 per cent of the precipitation can be utilized, or a total of about 2,000 million gallons. The total amount of water used by the city during 1913 was about 2,050 million gallons, and this amount is increasing from year to year.

This approximate analysis shows that even at the present time storage of water in the North Pond would have to extend over more than one season in order to assure an adequate supply in a very dry year, after the diversion of drainage contemplated by the improvements now being carried on.

Under the present agreement, the Watuppa Reservoir Co. can draw water from the North Pond without any limitation until the pond is at about 40 in. below "full pond." It is evident, therefore, that under present conditions the North Pond cannot be used by the city in storing water from year to year for water-supply purposes, and there is likely to be a shortage of water at any time after the diversion works are completed.

The additional problems before the Reservoir Commission are, therefore, first, to obtain for the city complete control of the waters of the North Pond, and, second, to supplement the water supply from some other source. To assure an adequate water supply these measures must closely follow the diversion improvements now under way.

GOVERNMENT INVESTIGATIONS OF THICKNESS OF CONCRETE BASES FOR PAVEMENTS.

The Office of Public Roads and Rural Engineering has begun a series of tests at Arlington, Va., to determine the proper thickness of the concrete base for roads of different types when subjected to loads of different magnitudes and when placed on various kinds of sub-base. In view of the increasing intensity of wheel loads to which roads are now being subjected, the solution of this problem is becoming of great economic importance. Steps have been taken to mold slabs of varying thicknesses on several kinds of sub-base and test them to destruction, the load being applied through various kinds of paving surface.

Concrete roads are now being built throughout the country with numerous kinds of aggregate and under various construction methods. There is a noticeable difference in the amount of wear suffered by these surfaces, and it is a much-mooted question as to which kind of aggregate will prove most economical under particular conditions of traffic and location of source of supply.

In order to gain information of value in this connection, an instrument has been devised and constructed in the concrete laboratory at Arlington, Va., for the purpose of measuring the amount of wear of concrete roads of different types. Periodical wear measurements will be taken of concrete-road surfaces on which the traffic conditions are known.

It has long been known that concrete is not elastic, but attains permanent deformation under working loads. During the course of a series of tests on reinforced concrete slabs recently made by the Office of Public Roads and Rural Engineering, and now being continued, it was very forcibly brought to the notice of the observers that the concrete continued to deform slowly as long as the load was applied. This fact is significant, as it helps to explain certain stress conditions in concrete roads and bridges when subjected to temperature changes. In order to study this phenomenon more fully, a series of tests has been begun to determine the "flow" of concrete and reinforced concrete when subjected to direct compression and to bending stresses. Working conditions will be maintained on the specimens as long as they exhibit "flow," and finally the specimens will be broken in comparison with like specimens that have not been previously loaded.

A NEW CEMENT SHOW FEATURE.

A feature of the Cement Show to be held in Chicago, Feb. 12-19, 1916, will be a joint exhibit by cement manufacturers of concrete products. There will be five general divisions in this exhibit:

(1) The road division will contain models, actual sections and ample data to give the visitor a clear conception of concrete pavement types. A recent government model showing the method of road building will be particularly interesting. Another model contrasting paved and unpaved alleys should make clear that the building of concrete alleys is an important move for civic betterment.

(2) The structural and decorative division will show examples of interior and exterior decoration, as intricate in character as the Hollenden Hotel (Cleveland) panels. Cast concrete specimens typical of the work which architects, particularly in the east, are using in distinctive work, will be shown. Surfacings with special aggregates and with characteristic treatments will be displayed in a manner which will show both the finished surface and the processes of production. Photographs and charts to bring out the lessons of the Edison and Salem fires will be shown in this booth.

(3) The rural contractor division will bring out the possibilities of concreting in rural districts. With the demand for concrete already created, the small town contractor should find the farm exhibit of especial benefit.

(4) The concrete unit division will treat of the methods of surfacing concrete units. The processes of bringing out the colors and brilliance of aggregates should interest architects and builders. A unit bungalow designed by one of Chicago's foremost architects will be the feature.

(5) The good concrete division will demonstrate by means of a 2,000 lb. testing machine and other laboratory apparatus that a better and more economical concrete results from the use of graded aggregates than from bank run materials. Full sized cylinders of clean and unclean aggregates will be used in the tests.

DATA ON STRADDLE DITCH EXCAVATORS IN DRAINAGE WORK.

By D. L. Yarnell, Drainage Engineer, U. S. Department of Agriculture.*

A machine of this type often used has a 30-ft. boom and a 1-yard dipper. The steam power used is obtained through a 2-cylinder, 35-hp. engine and a vertical boiler. The machine rests on a platform which is mounted on two steel beams, each 29 ft. long, that straddle the ditch. It can be mounted on either caterpillar tractors or wheeled trucks. In the latter case, each end of the two beams is supported on a two-wheeled oscillating truck, the wheels being 2 ft. high and 18 in. wide. They run on a wooden track 6 in. thick and 3 ft. wide, which is built in six sections each 20 ft. long. One section of the track on each side is always unoccupied and these are lifted ahead by means of cranes operated by power derived from the engines. This track will support the machine in the softest ground. The excavator will dig 12 ft. deep and 22 ft. wide on firm ground; with an extension to the dipper handle it can dig 18 ft. deep. It will deposit the dirt on either side at a distance of 32 ft. from the center of the ditch. The dipper will swing over a bank 14 ft. high. Where track is used the machine is pulled ahead by a cable from the engine which hooks to the track on both sides; this is done without interrupting the work of excavating. If desired, caterpillar tractors are furnished instead of the wheeled trucks. The front tractors are 4 ft. wide by 11 ft. long, and the rear tractors are 4 ft. wide by 7½ ft. long. This excavator has been known to dig as high as 1,500 cu. yd. in 10 hours in especially favorable material. It has dug through 12 in. of frost. From seven to eight men can set up and take down the machine in from five to eight days.

Another machine of this type has a 38-ft. boom and a 1-yard dipper. Power is supplied by an internal-combustion engine of 25 or 40 hp. which burns kerosene, gasoline, or distillate oil. The machine rests on a platform which is mounted on two steel beams, whose standard span is 32 ft. Extension axles are provided which permit of a maximum increase of 3 ft. in the span. The front axle is mounted on a two-wheeled swiveling truck with cast-steel double-flange wheels. The rear end is carried by two heavy, wide-faced, double-flange steel wheels set loosely on the axle. The shipping weight of this size of dredge, including engine, dipper, and machinery, is approximately 38,000 lb.

---

*Extract from Bulletin No. 300, Office of Public Roads and Rural Engineering, on Excavating Machinery Used in Land Drainage.

Perhaps the cheapest straddle-ditch excavator of the dipper type that is in use is a home-made one which has been used to some extent on small ditches in Iowa. The machine is of the revolving type. It is equipped with a ¾-yard dipper and a 28-ft. boom. The power is derived from a 6-hp. gasoline hoisting engine geared to three hoisting drums, one of which hoists the end of the dipper, one hoists the boom, and one pulls the machine ahead. The machinery is mounted on a platform which revolves upon a turntable supported on two wooden beams which straddle the ditch. The beams rest on wooden wheels, the entire span being 22 ft. The dipper handle, instead of moving forward and backward at the boom, is pivoted. The entire machine weighs only about 17,000 lb. and costs about $1,200.

This excavator has dug as high as 400 cu. yd. a day, but averages about 200 cu. yd. It can excavate a ditch with a 20-ft. top and can dig 13 ft. deep, but 6 or 7 ft. is the best working depth. Two men can erect the machine in 2½ days and dismantle it in ½ day; it makes about seven wagon loads. The hoisting apparatus, which is the heaviest part of the machine, weighs 4,100 lb. The excavator is moved ahead by means of a "dead man" and cable, and can be moved across country at a speed of about 1 mile per day. The machine can take out five shovel-loads in two minutes, and has dug through 6 in. of frost. Only two men are required to operate it—one operator and one trackman.

A ditch constructed by this machine in Iowa had an 18-ft. top, 4-ft. bottom, and 6½-ft. depth. From 8 to 10 gal. of gasoline, costing 16½ ct. at the works, were used per day. The material, which was a loam underlain by a stiff gravelly subsoil, was excavated at the rate of about 200 cu. yd. in 10 hours. The cost of operation per shift was as follows:

One operator	$4.00
One trackman	2.00
Ten gallons gasoline, at $0.16½	1.65
Total	$7.65

The cost per cubic yard, exclusive of interest and depreciation, was about 3.8 ct. The contract price on 5,000 cu. yd. was 12 ct.

Such a machine as this would be well adapted to digging the small ditches in the South that are almost universally put in by hand at a cost of about 25 ct. per cubic yard. Even in ground covered with stumps, by using plenty of dynamite this type of excavator could be used to advantage in reducing the cost of small ditches.

In general, it may be said that the dry-land dipper dredge, though applicable to certain conditions, has no extensive use in drainage work, as excavation that is suitable to this machine can usually be handled to better advantage by the drag-line scraper excavator.

METHOD OF KEEPING A GRAPHIC COST-PROGRESS RECORD ON SEWER CONSTRUCTION.

Contributed by W. A. Bennett of the J. B. McCrary Co., Engineers and Contractors, Atlanta, Ga.

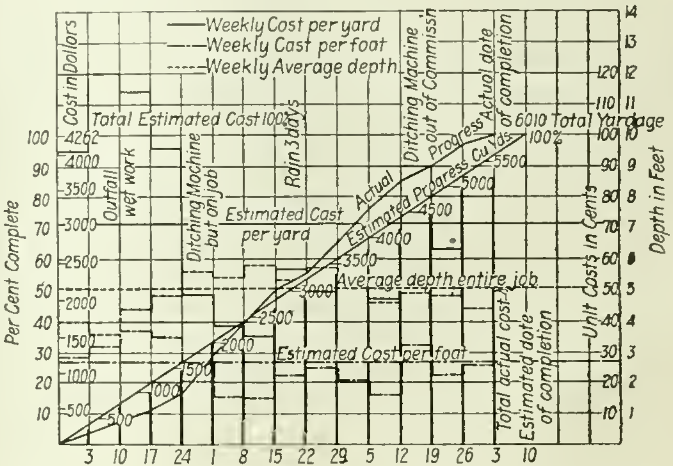
Every contractor who has been in the sewer game any length of time has come to realize (often to his sorrow) the importance of a continuous check on the cost of this kind of work, while the same is in progress. Sewer construction probably more than any other kind of ordinary construction work involves an element of hazard which makes it essential to keep in close touch with the cost so that any tendency to exceed the safe limit can be detected when it first develops.

The present article describes a graphic method for showing at a glance the essential points in the cost of a job, which has been found by the J. B. McCrary Co. to be very helpful in keeping track of a large number of jobs with the greatest degree of intelligence and the least amount of effort, and is offered in the hope that it may be of value to others interested in this line of work.

The graphic method has a distinct advantage over a written one, first in that the information is conveyed with less mental effort, is seen more clearly and therefore remembered longer; second, the chart shows the progress of the job from the beginning to date, showing at a glance the improvement or retrogression; and third, the desired information can be obtained more quickly.

This graphic record or progress chart, as it has been named, is made up from the data compiled in the cost record department with very little additional calculation. Under the cost keeping system which has been in use for several years, reports are turned in every day giving the quantity of work performed in each classification and the segregation of each man's time. This information is reduced to a money basis every day and the figures are entered in the cost record of the job under the various classifications, as this has been found simpler as well as more accurate than segregating the time once a week.

At the end of each week the cost record is balanced and checked with the payroll and the weekly cost data are taken off, showing the quantities of work performed, the total and unit costs for each classification as well as the corresponding items in the estimate for the job. It was previously the practice in figuring the unit costs to show only the average of each unit for the entire job to date, but it was found advisable to show in addition the cost of each item during the preceding week. The reason for this is obvious since, after the job is fairly well along, a very material increase in the unit cost would not affect the average for the job enough to attract attention, and this would be especially true if the amount of work completed during the week was small, which would be the case when unusual difficulties were encountered—the very condition which it is desired to have the cost data reveal.



Example of Graphic Cost-Progress Record Kept on Sewer Construction by the J. B. McCrary Co. of Atlanta, Ga.

It is a synopsis of these last items that the progress-cost chart is designed to show. The items plotted are the following:

The cost per lineal foot.
The cost per cubic yard.
The per cent complete (based on cubic yards of excavation).
The average depth.
The total cost to date.

Each time a job is started one of these charts is prepared showing the estimated value for each of the above items, so that as the work progresses the actual costs can be readily compared with the estimate.

The cost per yard referred to is not the cost of excavation alone, but the total cost reduced to the basis of the cubic yards moved and replaced in the work completed to date, and the cost per foot is the total cost reduced to a per foot basis. Since at the end of each week there will usually be a certain amount of trench opened up in which pipe has not been laid and some pipe laid and not backfilled it is necessary in order to get the most accurate figures to credit the cost for the week with the cost of these items. This latter is figured at the unit costs for these classifications during the previous week. Thus if there are 500 yds. more of excavation than backfilling at the end of a certain week and the unit cost for excavation that week was $.225, then the sum of $112.50 is deducted from the total cost before figuring the unit to be plotted. Then in figuring the cost per yard the number of cubic yards backfilled during the week is used.

Up to a certain depth it will be found that in most cases the cost per yard decreases with an increase in depth which would be just the reverse with the item of excavation along. This is due to the fact that the cost of pipe laying, hauling, etc. (a constant quantity at all depths), is relatively large at shallow depths. After the cutting gets below about 10 ft. this apparent inconsistency disappears. For this reason it seems that the most intelligent interpretation of the chart is had by observing the cost per foot, with the proper mental reservation for the depth of the work, using the cost per yard only as a second check.

Referring to the chart shown herewith it will be seen that the progress line is plotted in per cent of the total yardage estimated for the job, while the total weekly cost is plotted in per cent of the total estimated cost. As these two ordinates are superimposed it is evident that if the black bar representing cost to date always terminates below the oblique line representing progress, the job will necessarily be completed within the estimate. The distance between these two represents the margin of safety. Ordinarily it will be small at the beginning of the job, due to the cost of getting organized, and will be partially used up near the end, due to dressing up, cleaning and other items of "winding up," which do not show up in cubic yards. As long as this margin is great enough to care for these items the job is safe.

The charts are plotted in colors and are hung in a rack on the wall ready for reference. They have been found to be a great help to the administration of the construction department as well as making an interesting display.

ECONOMIC DESIRABILITY OF EXPERT OPERATION AND MAINTENANCE OF DRAINAGE PUMPING PLANTS.

By G. M. Woodward, Drainage Engineer, U. S. Department of Agriculture.[*]

It has long been recognized that in the construction of drainage improvements the services of men who make the planning and the supervision of such work a specialty is a business necessity. State drainage laws require that such men be employed on districts organized under the law. It is to be regretted that such laws do not also provide for engineering supervision of the operation of the pumping plant and in the maintenance of all the drainage improvements. The successful and economical operation of the pumping plant and the proper maintenance of the plant and the other drainage improvements require the careful and constant attention of those who are especially fitted by training and experience to do such work. On many districts examined the operating expenses of the pumping plant were unnecessarily large, the drainage improvements were rapidly deteriorating, and large damage had occurred from the partial or complete failure of some of the improvements. Such districts did not have proper supervision.

The present system of having a number of commissioners responsible for the administration of the affairs of the districts is wrong. Much is lost by this division of authority, and responsibility for any feature of the administration is hard to fix. Someone should be hired by the district to have full charge of the administration of the district business, and he should be made entirely responsible for the success of such administration. As an example of the divided authority, the records of one of the districts on the Illinois River showed that in the building of a house for the storage of coal at the pumping plant more money was spent in commissioners' expenses than in the construction of the storage house. An examination of costs of the various items for pumping per acre per year, will show that the lowest cost of operation and also of administration is found where the district employed engineering supervision and the business of the district was all in the hands of such supervision.

While the need is great for such supervision over all of the drainage improvements it is especially great for the pumping plant. A good pumping plant will often be wasteful, because it is improperly operated. After installation it should be thoroughly tested at various stages of the river, so that the proper operating conditions can be definitely determined. A competent engineer should be placed in charge of the plant, and he should report daily to expert supervision by a complete system of records. From such records it may be possible to devise improved methods of operation or ways of securing greater economy. Without such records it is impossible for anyone to tell in what particulars the operation of the plant is wasteful or is susceptible of improvement. Such a record should show the time of starting and stopping the pumps each day, the heights of the water levels within and without the district, the speeds of the pumps or engines, and the amounts of the boiler feed water and fuel consumed. It should set forth all incidents of importance in the operation of the plant, and may be kept in a form similar to that shown in Fig. 1. One page should be used for each day. The gages should be read before the pumps are started, again as soon as the ditch level has reached a fairly steady state, and at every hour during operation. If more than one pump is in operation the speed of each should be recorded. All additional matters should be recorded in the remarks column. An accurate rainfall record should be kept at every plant. The expenses of operating the plant should be carefully kept under the following headings: Fuel; labor; supplies, such as lubricating oil, waste, etc.; repairs; and superintendence. These expenses should be totaled for each month and for the whole season.

FORM FOR DAILY PUMPING RECORDS.

Date,............................

Hour.	Ditch gauge	River gauge	Lift.	Speed of pump	Steam pressure.	Rainfall.	Remarks.
	Feet.	Feet.	Feet.	R. P. M.	Lbs.	Ins.	
....	......	......	......	......	......	......	....
....	......	......	......	......	......	......	....
....	......	......	......	......	......	......	....
....	......	......	......	......	......	......	....

Fig. 1.

The keeping of proper records for a pumping plant is as important as is bookkeeping for a merchant. Failure to do so will mean loss, just as surely in the first case as in the second. Many districts have already suffered from this omission, and unfortunately very few of the districts are profiting by this costly experience. The landowners within the districts should demand of those in charge that such records be kept.

Many districts have followed the shortsighted policy of employing a cheap man to operate the plant during the pumping season and then allowing the plant to be without an engineer for a large part of the year. Such plants have deteriorated very rapidly and are becoming increasingly more expensive to operate. In the end it is much cheaper to employ a competent man by the year, furnish him with a good house, and make conditions attractive enough to hold the same man for a term of years. The plant on the Louisa-Des Moines District has been operated for about five years; it has been in charge of the same man for the entire period. While the salary paid the engineer has been twice th amount that many other districts pay, it has been money well invested, as the plant is now in almost perfect condition and has the appearance of a new plant. Figures already quoted show that the economy of the plant was better in 1913 than it was in 1910. If by careful operation and maintenance the depreciation of such a plant could be decreased from 6 per cent to 5 per cent, a saving of $500 a year would be effected. It is certain that the depreciation on many plants which have been carelessly operated during the pumping season and neglected the remainder of the year is at least 10 per cent. On a plant of this size this difference in rates of depreciation would easily pay the salary of a first-class engineer.

---

[*] Extract from Bulletin No. 304, Office of Public Roads and Rural Engineering, on "Land Drainage by Means of Pumps."

THE FAILURE AND RIGHTING OF A MILLION-BUSHEL GRAIN ELEVATOR.*

By Alexander Allaire, Western Manager, The Foundation Co., Ltd., Winnipeg, Can.

This article describes and illustrates the methods and equipment used in straightening a large reinforced concrete grain elevator which had tipped at an angle of about 27°, due to the failure of its foundation. The elevator, which has a capacity of 1,000,000 bu., is owned by the Canadian Pacific Ry., and is located at North Transcona, about seven miles northeast of Winnipeg, Canada. The work of restoration consisted of making safe the foundation of the work house, straightening the bin house, and providing the bin house with a new and adequate foundation. The article will be presented in two parts; Part II will be published in our issue of Feb. 2, 1916.

I.

Design Features and Subsoil Conditions.

The general layout consists of four units: a work house, 70 by 96 ft. and 180 ft. high; a bin house, 77 by 195 ft. and 102 ft. high; a dryer house, 18 by 30 ft. and 60 ft. high; and a boiler room equipped with two 100-hp. locomotive boilers. The work house rests on a reinforced concrete floor, 30 in. thick, and is a reinforced concrete structure, with brick curtain walls as the top is approached. The basement of the building is 16 ft. high. In it are the belts for transferring the grain from the cars to the conveyor-boots, and from the bin house to the work house. The ground, or prairie-level, floor is occupied by the cleaning and drying machinery. Above these ma-

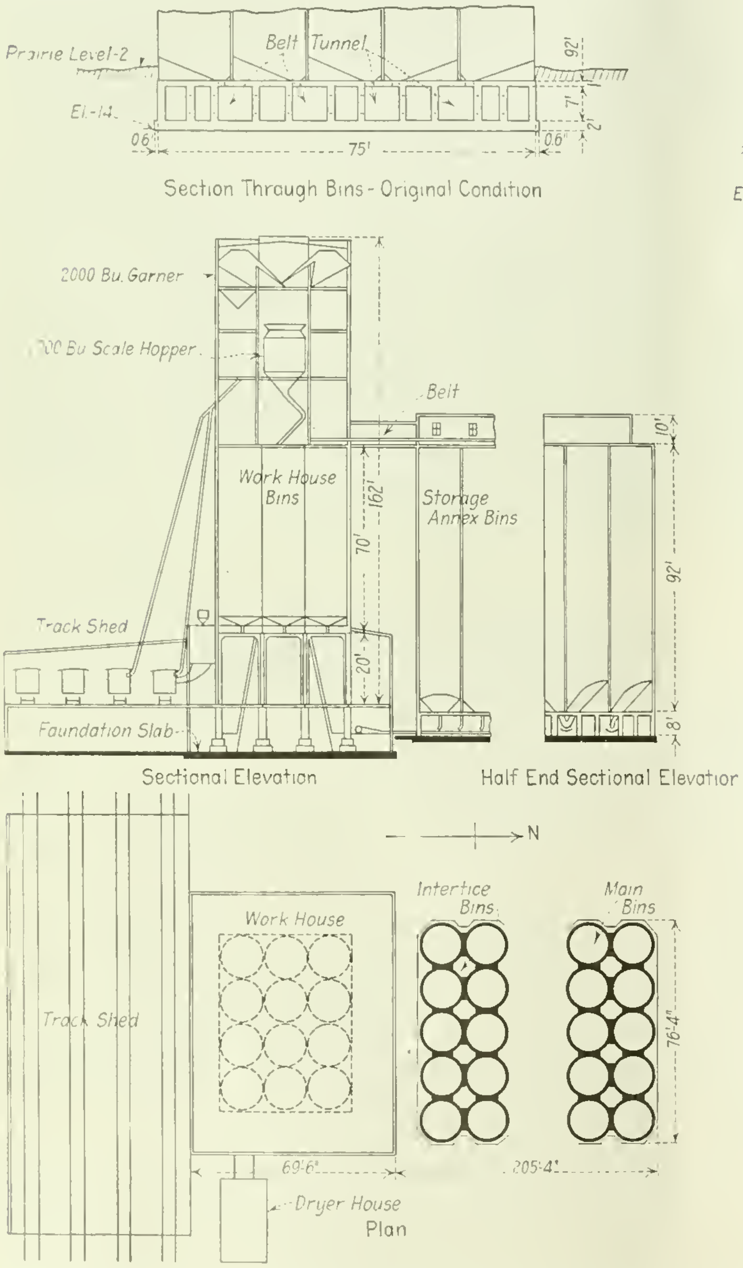


Fig.1

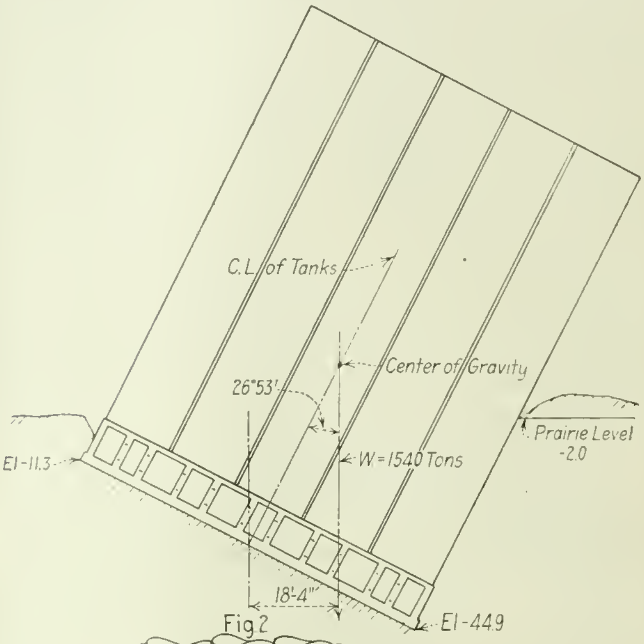


Fig 2

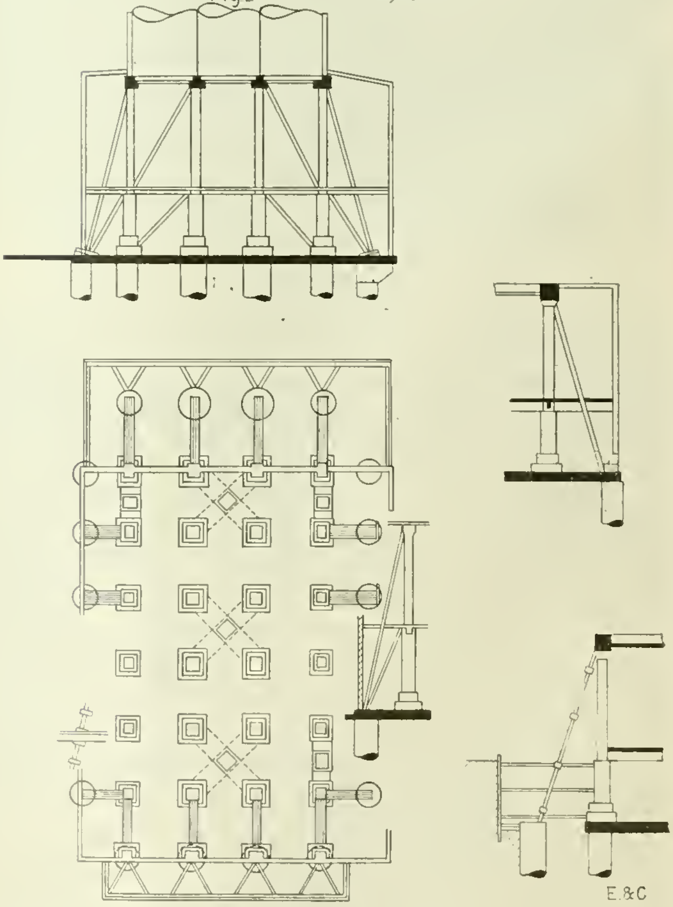


Fig.3

FIGS. 1-3—GENERAL DESIGN DRAWINGS AND SKETCHES OF REINFORCED CONCRETE ELEVATOR PLANT AT NORTH TRANSCONA, CANADA, THE FOUNDATIONS OF WHICH FAILED AND WERE RECONSTRUCTED.

Fig. 1—General Design Drawings. Fig. 2—End Elevation of Storage Bins Showing Extent of Tipping and Settlement. Fig. 3—Plan of Shoring and Underpinning Foundation of Work House.

---

*From paper in Proceedings, American Society of Civil Engineers, Vol. XLI, p. 2733.

chines there are 15 bins, 13 ft. in diameter and 70 ft. high, above which again are several floors carrying the weighing machines, etc. The floor, machinery, and wall loads above the second floor rest on 24 interior columns, placed in four rows of six columns each. The interior columns carry a load of about 800 tons each; the exterior ones carry about 500 tons each. Figure 1 shows the work house in plan and elevation.

The bin house, immediately north of the work house, consists of 65 circular bins arranged in five rows of thirteen each (see Fig. 1). These bins or tanks are 14 ft. 4 in. in diameter. The diamond-shaped spaces formed between the circular bins are also used for storage, each having a capacity of about 5,000 bu. The bins, 92 ft. high, are surmounted by a cupola which houses the top conveyor and trippers, and extends the full length of the structure. With this the tanks are filled with grain. The bin walls are of concrete, 6 in. thick, with the customary reinforcement. Below the 12-in. reinforced concrete slab, which constitutes the bin bottoms, there are four conveyor-belt tunnels, 7 ft. wide, running the full length of the structure. These tunnels are formed by walls 16 in. thick and 7 ft. high, which rest on a 2-ft. mattress of concrete. Transverse to the main tunnel walls there are 15-in. cross-walls approximately 15 ft. from center to center. These are under the bin contacts. The tunnel or cross-walls were not bonded to the floor or bin slabs, and this constituted a considerable hazard during the straightening.

The country in the vicinity of Winnipeg is flat, and the character of the soil is quite uniform throughout the district. First there is a stratum of about 2 ft. of heavy black loam, below which there is reddish gray clay, 5 or 6 ft. in thickness, and generally water-bearing, and this gradually changes to a blue clay extending to a depth of approximately 40 ft. below the surface, where it changes suddenly to white clay interspersed with limestone boulders. Underlying the white clay is found a stratum, averaging about 30 in. thick, of shattered limestone which in turn overlies the limestone rock. At Transcona this rock varied from 53 to 55 ft. below the prairie level.

Usually the blue clay found at the depth from 7 to 8 ft. below the surface is very firm, and is capable of carrying a load of from 3 to 4 tons per square foot. As a result it has been the practice in the Canadian Central West to use floating foundations. In building the elevator, therefore, this general custom was followed.

The ultimate loading of the clay under the mat was calculated at 3.3 tons per square foot. As a matter of precaution, soil-loading tests were made at different points on the site. From the result of these tests it was thought that the customary slight initial settlement might be experienced, but that nothing more serious should occur.

Excavation for the structure had been made to a depth of 12 ft. below the prairie level.

The dryer house had broad footing courses under the walls. Although it was deemed advisable, later, to underpin this building, this presented no difficulty.

Character and Extent of Failure.

The Canadian Pacific Ry. commenced storing grain in the bin house in September, 1913. Considerable care was taken to regulate the filling of the different tanks so as to distribute the load uniformly. Settlement began on Oct. 18. The bins at this time contained about 875,000 bu. of wheat. A vertical sinking of 1 ft. occurred within an hour after the settlement was first noted. This was followed by an inclination toward the west, which increased until, at the end of 24 hours. the bin house rested at an angle of 26° 53′ from the vertical (see Fig. 2).

An examination showed the east side to be 5 ft. above, and the west side 29 ft. below, the original position; the building was also approximately 4 ft. lower at the north than at the south end. An upheaval of 5 or 6 ft. of the ground surrounding the bins occurred during the settlement. At an angle of 26° 53′ the center of gravity of the loaded structure had moved over almost to the low edge. The upheaval and the compacting of the soil along the west side saved it from completely falling over. Above this, on the west side, 52 ft. of tank overhung the ground. This overhanging load, due to the grain-filled tanks, was considerable.

A careful examination was made of the structure and, remarkable as it may seem, practically no shear cracks were found. It was decided, therefore, that the first problem was to save the wheat. This was done by tapping the most westerly row of tanks at approximately the ground level and bleeding out the grain upon a belt conveyor parallel with the line of the tanks. When the tanks of this outer row were emptied down to the ground line, holes were tapped in the next row, and the grain was spouted to the belt conveyor, and so on from tank row to tank row. The hazard of this operation will be realized when one considers that it was difficult to calculate what stresses were set up, due to the inclined position of the bins and the change in loading as the tank rows were emptied in succession. Added to this was the menace, at the top of the structure, of the remnants of the cupola, part of which had fallen to the ground during the settlement. To remove the grain below the ground level, a sheeted pit was excavated at the north end. A conveyor leg was placed in this pit, with the discharge end emptying upon the belt parallel with the west side of the bins. The tanks were emptied by spouting the grain to the tunnel belts, which, being reversed, carried it to the conveyor leg. It is worthy of note that, despite the handicap of the dangerous working, and the fact that part of the conveying apparatus had to be obtained from Chicago, all the wheat was removed in less than three weeks from the time of the failure, and at a cost of less than 1 ct. per bushel.

Immediately after the failure an examination was made with boring machines, and it was found that, though the rock over the greater area was at a depth of from 52 to 55 ft. below the prairie level, an unusual condition existed along about one-half of the length of the east side of the bins—a ridge of boulders some 12 ft. higher than the rock being encountered. This was the reason for the tipping over, for, as the initial vertical settlement took place, resistance was offered along the east side, probably through compacting the soil above the ridge of boulders. This produced a tendency of the building to cant to the west. The heavy load caused the clay to flow and the structure to settle.

Fortunately the work house was only slightly affected by the movement of the bin house. Only a few cracks showed in the north shed wall, no settlement taking place in the building proper.

Righting of Work House.

In December, 1913, The Foundation Co., Ltd., of Montreal and Vancouver, submitted a plan to the engineers of the railroad for underpinning the work house to rock, as it was feared it might fall. The plan was approved, and the work was started immediately. In general the plan followed was the sinking of a pier under each column of the building. Because of the heavy loads, the height of the structure, and its small base it was necessary to shore the building before starting the underpinning operations at the 24 columns.

The shoring consisted of pushers from 20 small piers placed outside the building columns, as shown in Fig. 3. On account of the uncertainty of the condition of the material through which the piers would have to be carried it was decided to eliminate any risk by sinking the first six with cast iron shoring cylinders. The cylinders were 4 ft. in diameter and built up in 3-ft. sections. Flanges were cast at each end of the sections for making connections. The one exception to this was at the bottom section, on which one flange was omitted, the unflanged rim being used as a cutting edge.

The shoring piers on the south and east sides were placed under the shed walls. Work on these was started by cutting a hole 4 ft. 6 in. square through the concrete floor, then drifting to the site of the pier. This excavation was sheeted, and the first section of the cylinders was placed in position. As the earth was excavated from within the shoring cylinders, the latter were jacked down with 100-ton jacks. When the top of each cast iron section reached the ground level, another section was bolted on, and the operation was repeated. As a result of sinking six wells at different points throughout the area of the building it was decided that the Chicago well method, using wells 5 ft. in diameter, could be adopted.

The wells, with the exception of those on the south and east sides of the building, were placed clear of the walls. On the north side the work was carried on by cutting through the mat and sinking the wells immediately under it. At the west side of the building a sheeted pit was dug, approximately to the mat level, and the wells were started from this elevation.

Considerable water was encountered in sinking a majority of the shoring and underpinning wells. This was handled by No. 3 Pulsometer pumps, in some instances as many as three being required in a single well.

On each completed shoring cylinder there was placed a heavy timber shore. These were built in most cases of six 12x12-in. timbers, 40 ft. long, tied together with bolts and plates. Each pusher was heeled on oak blocking, placed on the top of the shoring pier at the basement floor level. Passing through an opening cut in the floor of the work house at the prairie level it engaged an oak header, reinforced on two sides with 12-in. channels, the header being let into the column just below the bin floor by notching out the mushroom top. Supplementing this was another pusher, extending from the shoring pier to the wall column at the first floor, and from this floor to the top of the interior column at the second-floor level.

Similar shores were placed on the shoring piers on all four sides of the building. These, combined with the columns, bin floor, and reinforced mat, formed a truss arrangement by which the load of the building was largely transferred to the shoring piers. Later, while the interior piers were being sunk, timbers (shown by the dotted lines of Fig. 3) were put in to take the load from the interior column bases.

After the shoring had been placed the work of sinking the 5-ft. wells under the wall columns and the 6-ft. 6-in. ones under the interior columns was commenced. The columns are 15 ft. from center to center. To gain access to the underside of the exterior columns holes 3 ft. 6 in. square were cut through the concrete floor mat between pairs of columns. Drifts 4 ft. wide and 6 ft. deep were driven in the direction of each column. As a well site was reached the space was enlarged to a circular area slightly greater than the outside diameter of the well lagging. These drifts or tunnels were sheeted to prevent loss of ground, and they afforded the only means of communication with the wells. The excavated material was hoisted in light galvanized metal buckets which traveled on curved tracks or skidways, necessary on account of the center of the top of the underpinning well and opening in the floor being off center by 7½ ft. At the basement floor level the spoil was dumped into wheelbarrows, which were wheeled to a motor hoist, raised to the prairie level, and wasted at a short distance.

Prior to opening up the wells at the work house levels had been taken on the column footings. As the piers were sunk check levels were taken at regular intervals. As a further check on any movement a plumb bob weighing 280 lb. was suspended from the roof of the building down through an elevator shaft. The total distance was about 160 ft. The plumb bob was immersed in a tank of water which was prevented from freezing by an electric coil. The position of the bob was noted every day.

Wells under the interior columns were approached in the same manner, except that the holes through the floor mat were cut centrally with respect to four columns, and thus handled the wells under them by drifting to each site in turn as one after another of the wells was completed. The distance from the center of the floor opening to the center of each underpinning pier in this instance was 10 ft. 6 in. Special curved skidways were used for these wells also. In all cases single-drum hoists, electrically operated, and having a rope speed of 130 ft. per minute were used to elevate the excavated material.

Concrete, up to the top of the wells, was deposited through light 8-in. galvanized iron pipe, cut to short lengths to accommodate them to the necessary curvature. Above this elevation, and up to within 8 in. of the under side of the columns, concrete was shoveled into place behind forms, the near side of which was built up as the concreting progressed. After this concrete had set sufficiently, the remaining 8 in. were finished both by grouting and by ramming in fairly dry concrete.

The work house operations were completed by about the beginning of June, 1914.

(To be continued.)

CONJUNCTION OF GRAVITY MIXER WITH A HOISTING AND CHUTING TOWER.

The sketch, Fig. 1, affords a quicker understanding than can verbal description of a newly worked out combination of a Hains-Maier gravity mixer with a tower for hoisting and chuting concrete. The distinctive feature of the arrangement and the one which makes it rapid and positive is the requirement for raising and lowering the topmost hopper. By means of the hoist and hinged guide arms the hopper is lowered to receive its charge at ground level and then hoisted to position over the other hoppers to perform its part in the mixing process. A recent installation of this combination has recorded unusual success. The arrangement has been worked out by the Automatic Concrete Mixing Co., Inc., Providence, R. I.

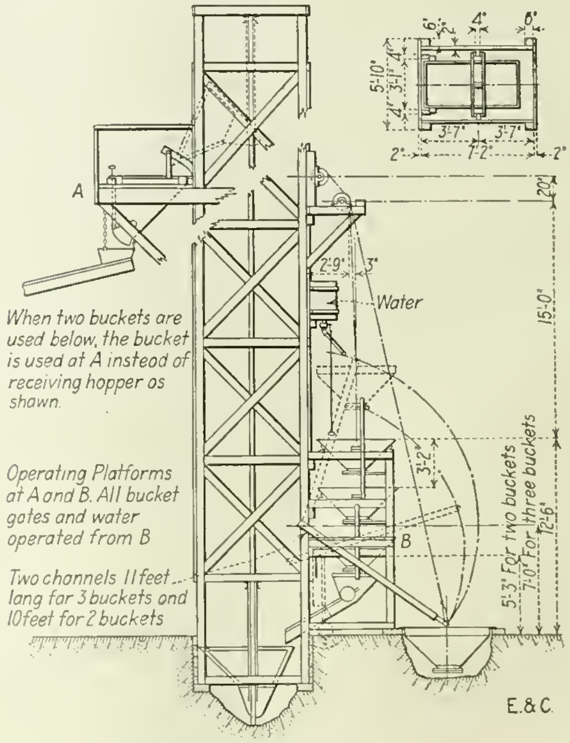

6"
4"
6"
5'-10"
4"
3'-1"
4"
3'-7"
3'-7"
2"
7'-2"
2"
A
20"
2'-9"
3"
Water
15'-0"
When two buckets are used below, the bucket is used at A instead of receiving hopper as shown.
3'-2"
Operating Platforms at A and B. All bucket gates and water operated from B
B
Two channels 11 feet long for 3 buckets and 10 feet for 2 buckets
5'-3" For two buckets
7'-0" For three buckets
12'-6"
E.&C.

Fig. 1—Gravity Mixer with Hoisting Tower.

National Gas-Safety Code.—The work begun some months ago in connection with a national gas-safety code has made good progress, and the United States Bureau of Standards is now receiving the co-operation of several engineering societies which have appointed representatives for the purpose. This gas-safety code will relate to both the life and fire hazard and hence will cover the ground which, in the case of corresponding work in the electrical field, is covered by two codes—the Underwriters' Fire Code, and the National Electrical Safety Code, which is being prepared by the Bureau.

Spherical Water Tanks.—In Germany elevated steel water tanks are often made spherical in form. This shape is doutbless adopted merely for the sake of appearance, since although a sphere can be built with less metal than a tank of any other form to have a given capacity, the extra cost of fabrication would probably more than compensate for the saving in material.

BOOK REVIEWS.

Water Power Engineering.—By Daniel W. Mead. McGraw-Hill Book Co., New York City. Cloth, 6x9 in.; 843 pp.; 437 illustrations; $5.

(Reviewed by George E. Ackerman, Manager Chicago Office for Gardner S. Williams, Consulting Hydraulic Engineer.)

This is a revised and greatly improved edition of Professor Mead's valuable and well known book on hydraulic work. It will be a welcome and nearly indispensable addition to the library of nearly every person who is interested in hydraulic engineering. Much material that was in the first edition has been omitted from the new book, but on the other hand much valuable material has been added. For instance the chapters on "Rain-Fall," "Run-Off" and "Stream-Flow" have been entirely dropped, which would have been unfortunate were it not for the fact that the author explains in the preface these subjects will be treated more fully in a later volume on Hydrology.

If every engineer who is entrusted with the responsibilities of designing and developing water power projects, would read this book and profit by the methods and advice given in the same, fewer blunders would be made in the building up of water power sites in the future and the general water power and hydro-electric business would assume a saner and safer foundation.

This book is not only based upon sound theory, but upon a valuable experience gained in many years spent by the author in the study of the subject and in the practical design and development of many water power projects.

Chapter 1 deals with the historical development of the subject. Chapter 2 deals, in an elementary way, with the questions of power and plant efficiency. Chapter 3 gives a valuable discussion of "Load Curves and Load Factors." This is a phase of water power engineering that is too often neglected by the average and superficial engineer. Chapters 4 and 5 contain much interesting information and data on the subject of Stream-Flow, and the different methods used to determine the velocities and losses in channels of various characters. Chapters 6, 7 and 8 discuss the Hydrograph and its application in general and specific cases. Especial emphasis is laid upon the use of the time distribution of flow curve, or as Professor Mead calls it "The Duration Curve." The reviewer believes, with Professor Mead, that this curve, when based upon several years' observations of flow, is one of the most valuable ways in which to show graphically the amount of water and the amount of power available and the probable most economical point of development of the power site. Chapters 9 and 10 describe and illustrate various types of water wheels and turbines and a few of the details of the same. These two chapters would be greatly improved if they were rewritten so as to drop the description and illustration of some of the antiquated types of apparatus covered, and include, instead, descriptions and illustrations of some of the latest and what have been demonstrated by actual tests in the field to be the best types of turbines and turbine details. More emphasis should be placed on the fact that the last few years have seen a wonderful change and advance in turbine design, and the influence that these changes are having on the general design of the water power plant. Especial mention should be made of the present tendency toward high speed in the design of low head turbines, and the future possibilities in this line of effort. Chapters 11, 12 and 13 deal in a fundamental way with the Hydraulics of the Turbine, and discuss various characteristics of speed, power and efficiency, and the inter-relationship of these three factors. Professor Mead introduces here a new expression, which he calls "Characteristic Power." This is a new term and is used by the author in a very interesting way. Chapter 13 is especially valuable to any engineer who has to solve the problem of choosing the correct turbine for a given installation.

The submission by the turbine bidder of data covering a test of the runner upon which he is bidding, or one of homologous design, at the Holyoke or some other standard testing flume, is desirable and in fact absolutely essential for a direct comparison of the power, speed and efficiency characteristics of the different turbines under consideration. The best practical method to use for this comparison is that of reducing all data to the same unit basis. Chapter 13 describes clearly a method for doing this.

Chapter 14 deals with the theory of water wheel governing and develops practical methods for solving the speed regulation question of both open flume turbines and closed penstock turbines, while chapter 15 describes somewhat in detail various types of governors which are now in the market. This chapter spends too much space and too many illustrations upon what is now the almost obsolete mechanical type of governor. This space might far better be given to more consideration of the Oil Pressure Governor, with its details, and the solution of several practical problems of governing in the case of both open flume and closed penstock units.

In chapters 16, 17 and 18, which are devoted to the arrangement of the Reaction Wheel, with the proper design of the plant and a description of numerous existing power plants, Professor Mead again falls into the error of devoting too much time to the older types of installation and giving too little space to the new types of installation which have been brought into use during the last few years. Especial attention should have been given in this chapter to the many advantages of the direct connected, single runner, vertical shaft unit in its various forms, for heads below 50 ft.

Chapter 19 deals in a satisfactory manner with the relation of the dam to the power house, while chapters 20 and 21 deal with the principles of construction of dams and their appendages, and give illustrations of numerous prominent developments. This is, of course, too big a subject to be treated comprehensively in one or two chapters, and Professor Mead has evidently made no attempt to cover the subject in anything other than an elementary way.

Chapters 22, 23 and 24 are devoted to consideration of the financial and commercial sides of the water power problem. We commend these chapters especially to the consideration of every water power engineer, and it would be well if every person who is financially connected with any water power project could read and digest the information therein given. Many of the past failures of water power developments have been due to the fact that the financial backers of the same have shared in the popular illusion that every undeveloped water power site is a gold mine.

Many valuable tables are given at the end of the book, and the tables showing Holyoke Tests upon different manufacturer's runners have been extended so as to include nearly all of the latest important tests at Holyoke. It is suggested that these Holyoke Test tables would be greatly improved if in each case they bore the Holyoke test number, thereby permitting the practicing engineer to identify a given test when the manufacturer referred to its number.

The tables on "Run Off" and "Rain-Fall," which were in the former edition have been omitted, but, as mentioned above, these will probably be in the new volume on "Hydrology."

The mechanical make-up of the new book is superior to that of the old edition, for although the new book contains more pages it is less bulky because printed on an excellent quality of thin paper.

Especial commendation should be given to the author for the exhaustive list of references at the end of nearly every chapter to other literature dealing with hydraulic subjects.

Text Book of Geology.—Part I, Physical Geology, by Louis V. Pirsson. Part II, Historical Geology, by Charles Schuchert. John Wiley & Sons, New York. Cloth, 6x9 in.; 1,051 pp.; illustrated. $4.

A study of geology is an essential part of the school training of the mining engineer. It receives scant place in the curriculum of the civil engineering student. As years of practice accumulate the civil engineer comes to know something considerable of geology, but this knowledge is as a rule confined to narrow and special fields.

For these two reasons alone it would advantage every civil engineer to read this work by Professors Pirsson and Schuchert. There is yet another reason, which is that these men tell the story of the geological records in an intensely interesting manner.

Thirty years ago in school the reviewer read his geology with more earnestness perhaps than was common among civil engineering undergraduates. A teacher with the power to arouse interest deserves most praise, it is probable, but whoever merits credit, the present writer at any rate came to know the writings of Le Conte and Dana and Lyell and Geikie and other masters of the science. To him the book whose title is named above was taken in hand prejudged. Good it might be, he was willing to grant, but that it could rival in interest the classics of his youth was of course impossible. In this mood he began to read, planning to read just enough to salve a book reviewer's conscience, and he ended with reading every word from preface to index. And when one must read perforce as a part of his work many books, it is the unusual book that thus commands through sheer interest complete attention. Lest the writer shall belie the oldest tradition of the brotherhood of reviewers that always one must mask all enthusiasm, he hastens to set down the qualifying statement that he reads geology not as a geological expert. Perhaps such a one will find errors in fact or at least opinions to dispute, but the reviewer was all unconscious of such detractions and so, he thinks, would be most civil engineers.

The main trunk of geology has many branches of which mineralogy, petrology and meterology are most familiar to engineers. Its roots are in the foundation sciences of physics and chemistry. Being a general treatise this book must round into one discussion something of these and other allied sciences—astronomy, botany, zoology. The main division of the text is at the line of differentiation between physical geology and historical geology. To the engineer as a professional the part on physical geology is likely to be most interesting. It deals with the elements with which the engineer is in contact in every item of his work as a constructor. Physical geology is a consideration of the earth structure and of those dynamic agencies—air, water, heat and life—which have operated and are still operating to form and modify that structure. Historical geology is the chronological story of those events, beginning with cosmos which have happened to the earth in all time. It is the more speculative side of the science.

Professor Pirsson's discussion of physical geology is predicated upon the modern thought that the known agencies at work today are competent to produce the relief features of the earth provided they have enough time. The old cataclysmic theory of earth formation is discarded. Thus in his first division of the text—Dynamic Geology—he discusses: The work of the atmosphere; of rain and running waters; of lakes and interior drainage; the ocean and its work; ice as a geological agency; the work of underground water; geological work of organic life; igneous agencies, volcanoes and hot springs; the work of earthquakes. These nine chapters can be read by the civil engineer with first-hand knowledge and familiarity with the forces at work, and the results of their labors. Weathering, erosion, chemical dissolution, sedimentation, wave action, ice disruption, organic deposition, heat contraction and expansion, etc., are familiar causes and effects in the engineer's work and he requires no teaching of fundamentals to be apprised of their power as forces for geological work. Dynamic geology, as considered by Professor Pirsson, describes and illustrates this work, and here it may be said that illustration as a co-ordinate part of descriptive text reaches a very high place in this volume. A full 200 drawings and photographs illustrate the 240 pages on dynamic geology.

The second division of Physical Geology as treated by Professor Pirsson is named Structural Geology. In this division he considers the material upon which the dynamic agencies previously considered have operated and the results of those operations in nature of rocks produced and in form and appearance in which these rocks present themselves. A chapter on general structure and properties of the earth is followed by six special chapters on sedimentary rocks; igneous rocks; metamorphic rocks; fractures and faulting of rocks; mountain ranges, their origin and history, and ore deposits. This section of 137 pages, with 111 illustrations, is the shortest section in the book. The direct professional interest of the civil engineer in this section is quite as great, however, as in any part of the book. Indeed, we venture the assertion that civil engineers are rare who, reading this section, fail to receive knowledge of value in their work.

Historical Geology in this book is the subject of Professor Schuchert, and its discussion occupies over 600 pages. Historical geology is based on sciences perhaps less familiar to the civil engineer than are physics and chemistry, which comprehend most of the agencies with which physical geology deals. On the cosmical side historical geology passes into astronomy and in the study of evolution of life on the earth something of an acquaintance with zoology and botany is needed. A most valuable feature to the lay reader of Professor Schuchert's treatment of his subject is the preliminary presentation in some 100 pages of the information needed to co-ordinate the student with these related or basal sciences. Then through 30 chapters the author leads the reader from event to event in the geological life of the earth—from nebula to man. The story is one of great and intensely interesting speculation and of even greater and more intensely interesting search for and disclosure of records. As in the sections on physical geology, extensive use has been made of illustration; no count is easy, due to grouping of drawings, but one estimates some 500 illustrations in text and on plates.

Irrigation Practice and Engineering.—Vol. I, Use of Irrigation Water and Irrigation Practice; Vol. II, Conveyance of Water. By B. A. Etcheverry. McGraw-Hill Book Co., New York. 1915. Cloth 6x9 in.; Vol. I, 213 pp.; Vol. II, 364 pp.; illustrated; Vol. I, $2; Vol. II, $3.50.

The year just passed has been fruitful in books of interest to the irrigation engineer and manager. This plenty has followed a dearth of many years. In 1913 Newell and Murphy published the first American book in almost a generation on Principles of Irrigation Engineering. We are not forgetting King's Irrigation and Drainage nor a number of smaller volumes in which irrigation has been discussed from the cultural side. None of these books was a book for the engineer of irrigation works. Indeed Newell and Murphy wrote more for the student in engineering and for the engineer seeking general information about irrigation than they did for the active practitioner in design and construction and operation of irrigation works. The crop of irrigation books of 1915 has been of a different kind. Most of them have been monographs; discussions of only one sort of task which the irrigation engineer has to perform or compilations of data for facilitating the solution of irrigation engineering problems. Of the latter kind is, notably, "Working Data for Irrigation Engineers," by Moritz, and of the former kind are, "Use of Water in Irrigation," by Fortier; "Practical Irrigation and Pumping," by Fleming, and "Construction of Masonry Dams," by Smith. The book, the name of which heads these comments, is the latest of the list and is of neither of the two classes into which the others fall. It is a general treatise on irrigation engineering works design and construction, planned with breadth and worked out with great thoroughness. It is a book which ranks with "American Sewerage Practice" by Metcalf and Eddy and with "Reinforced Concrete Construction" by Hool.

"Irrigation Practice and Engineering" is published in three volumes of which two are now being distributed and the third of which, "Irrigation Structures," is in the printer's hands. The present review refers only to the two volumes ready for delivery. Here, however, a brief explanation may well be made of the general purpose of the author and of the plan of presentation adopted by him. First, the book is a reference book for engineers as well as a text book for teachers and students. It is also written for the operator of irrigation works as well as for the designer and builder of such works. Again the book is primarily a treatise on American irrigation practice. Two of its distinctive features are: many dimensional drawings of irrigation structures and a most complete bibliography of reports and articles for collateral reading.

Volume I on "Use of Irrigation Water and Irrigation Practice" is more nearly a separate unit—complete in itself—than is either Vol. II or Vol. III. It is named an introductory volume by the author. His argument for its inclusion and for its position in the series is that the design and construction of irrigaton works cannot be conducted in the best manner unless the engineer is familiar with problems of operation. Reviewing the several chapters in order: Chapters I and II consider the disposal of irrigation water, discussing first soil moisture and plant growth, then water consumption by plants and soils and due to waste. Theoretical water requirements by different crops are considered in Chapter III and in Chapter IV is discussed economic use of water. Water duty is discussed with the presentation of many data in Chapter V. In Chapter VI begins the discussion of irrigation construction; distribution system and land preparation for the application of water. The final chapter of the volume is on selection and cost of small pumping plants. Summarized, Volume I is a consideration of irrigation water requirements, water use, water waste and water distribution. In part this volume covers the ground included in Fortier's "Use of Water in Irrigation" and in Fleming's Practical Irrigation and Pumping, but with this difference in treatment that Etcheverry writes more for the engineer, and Fortier and Fleming more for the irrigationist.

In Volume II the author begins his discussion proper of irrigation works design and construction. The first six chapters which may be called chapters on design have the following titles: Preliminary Investigations; Planning and Location; Hydraulic Formulas; Silt Problems; Conveyance Losses; Canal Cross Sections. These six chapters give all the essential tables, diagrams and formulas for canal, pipe line and gate design. In the succeeding four chapters the author discusses canal and pipe line construction; essentially these chapters are descriptions of canal and pipe line structures lavishly illustrated by selected designs with many data on construction methods and costs. The titles are: Canal Linings; Tunnels; Flumes; Pipe Lines and Siphons. There are upward of 200 illustrations in this volume, all of modern structures and all but a few of American structures.

The publisher's work on this book is excellent; each volume has a good index and all illustrations have ample descriptive captions.

Disposal of Sewage.—By Leonard Metcalf and Harrison P. Eddy. McGraw-Hill Book Co., New York City. Cloth, 6x9 in.; 850 pp.; illustrated. $6.

This is the third and final volume of the series of books entitled American Sewerage Practice. The book is addressed not only to engineers but also to sewer commissioners, lawyers and under-graduate engineering students. There are 20 chapters; the first six chapters are devoted to an explanation, in non-technical language, of the nature of sewage and the changes that take place in it. The remaining 14 chapters are addressed primarily to the designing engineers and to the operators of sewage treatment works. The subdivisions of the subject matter, as indicated by the chapter headings are: Progressive Steps in Sewage Treatment; Meaning of Chemical Analyses; Bacteria and Their Relation to the Problem of Sewage Disposal; Plankton; Composition of Sewage; Theories of Sewage Disposal and Treatment; Sewage Disposal by Dilution; Grit Chambers; Racks, Cages and Screens; Sedimentation, Straining and Aeration; Tanks for Sludge Digestion; Chemical Precipitation; Sludge; Contact Beds; Trickling Filters; Intermittent Sand Filtration; Irrigation and the Agricultural Utilization of Sewage and Sludge; Automatic Apparatus for Dosing; Disinfection of Sewage and Sewage Effluents; and Disposal of Residential and Institutional Sewage.

The treatment of the subject is as exhaustive as it can well be made in a single volume. The authors do not theorize at great length. Theories are stated but long and involved statements of opposing theories are not indulged in. The book is essentially a working manual with theory and practice nicely blended. The authors take the position, in effect, that while there is no doubt much yet to be learned in this field, present knowledge is sufficient to enable the engineer to build a variety of sewage treatment works which will produce satisfactory effluents at moderate costs. The book is for the student in and out of school who wishes to learn what is well known by experts regarding sewage disposal and who is content to leave all speculative and debatable topics to the research worker. The authors predict a progressive enlargement of knowledge of the subject, while conveniently recording knowledge down to date. They hold the view that the construction of needed works should not be postponed awaiting the further developments in the art.

English and German experiences are recorded but the bulk of the work relates to the practice of American engineers. The book is well illustrated with views of apparatus and of works and there are numerous line drawings of full plants and of parts of plants. Being the latest book it ought to be the best on the subject. It is easily that. It is exceedingly well edited. So well are its contents classified that it should serve admirably for class room use.

Water Purification Plants and Their Operation.—By Milton F. Stein. John Wiley & Sons, New York City. Cloth, 6x9 in.; 260 pp.; illustrated. $2.50.

This book gives detailed descriptions of various types of water purification plants and of their component parts, and gives directions for the operation of such plants. It is addressed primarily to the non-technical operator of small plants, and secondarily to graduate chemists who have some difficulty in applying their theoretical academic learning to the problems in applied chemistry encountered in the operation of water purification plants. The first class of operators will find especially helpful the instructions for preparing standard solutions, making bacterial and chemical tests of water, handling coagulants, washing filters and keeping records. The same class of operators will also greatly appreciate the charts showing the amounts of coagulants to use.

The text is divided into the following nine chapters: Water and Its Impurities; Types of Purification Plants; Physical and Chemical Tests; Bacterial Tests; Interpretation of Tests; Coagulation and Sterilization; Water Softening; Sedimentation; Filtration and General Operation.

The book is the first in its field and fills a well recognized want. It is primarily for the operators of rapid sand filtration plants. It contains but little matter pertaining to slow sand plants, and this is quite proper, since the slow-sand process has unquestionably been on the wane in this country for several years. Moreover, practically all small plants are of the rapid sand type and it is to the operators of such plants that a manual of this character will prove most helpful. The book will make for more competent filter plant operation. A feature which will be much appreciated by the non-technical reader is the plan of showing group photographs of all the pieces of apparatus required in making the various tests. The book abounds in helpful hints on a multitude of small points—just such things as the inexperienced operator would be most in doubt about.

The author makes no claims for his book as a textbook for use in engineering colleges. In the reviewer's opinion such a claim may be made with the utmost assurance. As a supplementary text for civil engineering students studying water supply engineering it will be found useful. To such students the three chapters relating to the making and interpretation of physical, chemical and bacterial tests are, of themselves, well worth the full cost of the book. Of course the book is even more appropriate for the use of municipal and sanitary engineering students.

Field Engineering.—By William H. Searles and Howard Chapin Ives. John Wiley & Sons, New York City. Flexible leather, 4x7 in.; 635 pp.; illustrated; $3.

The present edition (the seventeenth) of this old favorite has been extensively revised and enlarged. For those unfamiliar with the earlier editions the subtitle of the book: A Handbook of the Theory and Practice of Railway Surveying, Location and Construction, will serve to make clear the scope of the work. The book before us is subdivided into two volumes: text and tables. The fact that 53,000 copies of this work have been published, from 1880 to date, precludes the necessity of making anything in the nature of critical comment. It is a fair presumption that the railway engineers of this country know a good book when they see it. This great sales record attests the quality of the book and renders further praise at this time quite supererogatory. That being the case the plain duty of the reviewer is to set forth merely the new features of the latest edition.

In the seventeenth edition the changes made are so many that the entire text was set in type anew. The authors classify these changes under four heads as follows: (1) Minor changes in subject matter; (2) A rearrangement of certain portions of the book; (3) The abridgment of certain sections, and (4) The addition of a large amount of new material. All told about 150 pages have been added. Passing over the slight changes and over the portions merely re-written, it should be noted that the treatment of reverse curves, the spiral curve, earthwork tables and diagrams and haul and mass diagram is nearly or entirely new. The chapters on turnouts and crossings and calculation of earthwork have been both rewritten and extended. In the sixteenth edition there was but a single chapter on construction. In the present edition there are three chapters on construction: Cross sections, construction, and track laying. In these chapters new matter has been added.

Quite naturally the latest edition is an improved one.

Practical Track Work.—By Kenneth L. Van Auken. Railway Educational Press, Chicago. Cloth, 5½x8 in.; 215 pp.; illustrated. $1.50.

This is a book for the practical trackman. Engineering features of design were omitted as of no interest to trackmen. To keep the volume small it was necessary, also, to omit taking up the subject of maintenance of way. The book deals chiefly with the organization of track gangs and describes the actual steps to be taken in laying track and in putting in switches. The porcedure described is, in all cases, that which has been found to be most expeditious and most economical, and easily understood sketches illustrate the procedure to be followed. The matter is practically all original and is based on the experience of the author as a track laborer and foreman. The author was brought up on track work and knows it from A to Z.

There are nine chapters, as follows: Labor and Organization; Track Materials and Tools; Spiking, Bolting, Cutting and Curving Rails, etc.; Constructing Track on a New Line; Double Tracking; Relaying Track; Construction of Turnout, Ladder Tracks, and Crossovers; Slip Switches and Surfacing New Track. There is also an Appendix which tells how to lay out curves with the 50 ft. tape, a very full glossary of track terms, and numerous tables for the track foreman's use.

The book is a highly meritorious contribution to the literature of scientific management. It is very readably written. It covers every detail of track work from the driving of a spike to the operation of a track-laying machine. It should be in the hands of every section foreman. Ambitious and progressive foremen will probably buy it. It should be bought for the other kind of foremen and they should be directed to study it. Such a course, on the part of railroad companies, will pay a very large return on the investment in the books so distributed, in the form of better work at reduced costs. The book is unqualifiedly commended.

The Building Estimator's Reference Book.—By Frank R. Walker. Frank R. Walker, 30 N. Michigan Ave., Chicago, Ill. Flexible leather, 4½x6¾ in.; 592 pp.; illustrated; $10.

The work is intended to be a reference book for contractors and estimators engaged in estimating the cost of and constructing all classes of modern buildings. The scope of the book is indicated by the 26 chapter headings, which are as follows: General Conditions and Overhead Expense; Wrecking and Excavating, Caissons, Lagging and Concrete, Wood and Concrete Piles; Concrete for Footings and Foundations; Water and Damp Proofing; Concrete Floors and Pavements; Reinforced Concrete Construction; Brick Masonry; Rubble Work, Cut Stone, Granite and Architectural Terra Cotta; Hollow Tile Fireproofing; Rough Carpentry, Timber Framing, Lumber, Flooring, etc.; Mill Work and Interior Finish; Plastering; Fire Retarding Doors and Windows; Sheet Metal Work, etc.; Roofing, Slate, Tile, Composition, etc.; Exterior and Interior Marble, Slate and Scagliola; Interior Tiling, Floors, Wainscoting, Mantels, etc.; Glass and Glazing; Painting and Varnish; Structural Iron and Steel; Miscellaneous and Ornamental Iron, Brass and Bronze; Miscellaneous Building Specialties, Vault Doors, Prismatic Sidewalk Lights, Blackboards, etc.; Rough and Finish Hardware; Plumbing, Sewerage and Gas Fitting; Steam and Hot Water Heating; Electric Wiring.

The book is essentially a collection of cost data on building construction, many of the costs being compiled by the author while on the work during construction. All costs are stated to be thoroughly reliable and trustworthy, although the sources of information are not always given. The data are made more readily understandable by numerous illustrations. The book will be found of great value to those engaged in estimating and building various classes of buildings.

Materials of Construction.—By Adelbert P. Mills. John Wiley & Sons, Inc., New York. Cloth; 6x9 in.; 658 pp.; illustrated; $5.

This work is written primarily as an elementary textbook covering the manufacture, properties, and uses of the more common materials of engineering and construction. A systematic form of treatment of each material has been adopted, which consists first of a discussion of the ordinary application of the material in engineering construction, followed by a study of its manufacture or natural occurrence, and concluded by a discussion of physical and mechanical properties in their relation to its uses. The book is largely a compilation of data and opinions taken from many different books and publications.

The following eighteen chapter headings and the space devoted to each indicate the scope of the book: Gypsum Plasters, 1-18; Quicklime, 19-49; Hydrated Lime, 50-58; Hydraulic Lime, Grappier Cements, 59-69; Puzzolan Cement, Slag Cements, 70-78; Natural Cements, 79-89; Portland Cement, 90-171; Concrete, 172-201; Building Stones and Stone Masonry, 201-221; Bricks and Other Clay Products, 222-256; Pig Iron, 257-293; Cast Iron, 294-332; Malleable Cast Iron, 333-340; Wrought Iron, 341-359; Steel, 360-499; The Special Alloy Steels, 500-540; The Non-Ferrous Metals and Alloys, 541-604; Timber, 605-658.

The book will meet a need for a comprehensive and elementary text-book treating in a systematic manner of the manufacture, properties, and uses of the materials commonly employed in engineering construction. In most cases the data are sufficiently complete to make the book of value for reference purposes.

The Corrosion of Iron.—By L. C. Wilson. The Engineering Magazine Co., New York City. Cloth, 5x7½ in.; 175 pp.; $2.

This book contains a summary of the causes of the corrosion of iron and steel and a discussion of the preventive measures available. A scientific study of the nature of corrosion is of comparatively recent origin. The art of protecting iron and steel against corrosion has developed simultaneously with the study of the nature and causes of corrosion. Particularly is this true of paint pigments and vehicles. In recent years carefully conducted experiments have disclosed many fundamental facts of the greatest value regarding the nature and protective action of some of these rust arresting materials. Heretofore much of this valuable knowledge has been scattered throughout technical society proceedings and technical journals. The purpose of Mr. Wilson's book was to collect this scattered information in a form readily available to engineers. The book, therefore, records and classifies the more important facts connected with the corrosion of iron and steel, and the protection of these metals from corrosion.

There are seven chapters, as follows: The Rust Problem; Theories of Corrosion; Protective Measures; Paint Materials; Protective Paints; Influences of Different Elements on the Corrosion of Iron; and Corrosion of Wrought-Iron and Steel Pipe.

The book is very timely and deserves to be widely read by engineers. The protection of iron and steel against corrosion is one of the first duties of the engineer for the supply of raw materials is not unlimited.

Purchasing.—By H. B. Twyford. D. Van Nostrand Co., New York. Cloth; 6x9 in.; 232 pp.; illustrated; $3.

The purpose of the book is to treat of the economies which can be effected by the use of efficient methods in the purchasing of materials, goods and supplies. The following four subjects are treated in detail: Purchasing; The Purchasing Organization; Operation of Purchasing Department; and Purchasing as Practiced. Under the head of purchasing there are considered the principles of purchasing, the functional position of purchasing, and the ethics of buying. Four chapters are devoted to the purchasing organization, under the headings, The Purchasing Agent, The Purchasing Department, Organization of Department, and System of Procedure. In treating the operation of the purchasing department the following subjects are considered: Obtaining and Tabulating Proper Records; Work Connected with Requisition and Order; Invoices and Method of Handling; and Operation of Stores. The subject of purchasing as practiced is treated under the chapter headings: Purchasing for Railroad Work and for Operation of Electric Railroads; Purchasing for a Manufacturing and Construction Company; Purchasing for Construction and Operation in Widely Separated Localities; and Purchasing for a Small Manufacturing Establishment. By means of numerous forms and charts the information given is made readily applicable to business organizations. The book will be found helpful by those having to do with purchasing, and it is a welcome contribution to a subject on which there is little published information.

Further Problems in the Theory and Design of Structures.—By Ewart S. Andrews. D. Van Nostrand Co., New York. Cloth; 5½x8½ in.; 234 pp.; illustrated; $2.50.

This is an English work written as an advanced textbook for students and engineers engaged in structural work. The book supplements the author's previous work on the theory and design of structures. Practically all of the steps involved in the mathematical deductions have been given to simplify the work of the student. The first part of the text deals with influence lines, next there is presented the principle of work, and finally portals, wind bracings, and secondary stresses are analyzed. The scope of the book is indicated by the chapter headings, which are as follows: Influence Lines; Influence Lines for Simply Supported Frames; Influence Lines for Fixed and Continuous Beams; Influence Lines for Arches and Suspension Bridges; Internal Work: Deflections of Framed Structures; Stresses in Redundant Frames; Stresses in Rigid or Elastic Arches; Stresses in Portals and Wind Bracings; and Secondary Stresses in Structures.

The author's treatment of his subject is simple and clear, although the inclusion of practically all of the intermediate steps in the mathematical deductions is hardly warranted in some cases in view of the fact that the work is written for advanced students. The book will be found of value to students and engineers specializing in structural work.

Manual of Surveying for Field and Office.—By Raymond E. Davis. McGraw-Hill Book Co., New York. Leather; 4x6¾ in.; 365 pp.; illustrated; $2.50.

The book is a manual of the practice of surveying designed for the use of civil engineering students in their preparation for field and office exercises. It is intended primarily for use in conjunction with a treatise on surveying if the field and office practice is developed with the theory, or for short courses in surveying in which most of the time is devoted to field and office work. The first chapter deals with general instructions for field and office work, and emphasizes the more difficult and important parts of surveying. The remainder of the book, by means of field and office problems, progressively builds up the practice of surveying from elementary work with the tape to complete topographic surveys. In general, the problems are treated under the headings: Object; Procedure; Hints and Precautions; and Practical Applications. A sample problem in each case illustrates the manner in which the work is to be done and recorded.

The logical arrangement and careful planning of the problem assignments will be appreciated by those in charge of surveying classes. The sample problems are exceptionally well planned and executed, and the selection of tables is such as will ease and expedite the work of the student. The author has accomplished his aim to produce a satisfactory manual of surveying practice.

Railroad Field Manual for Civil Engineers.—By William G. Raymond. John Wiley & Sons, New York City. Flexible leather, 4½x7 in.; 386 pp. $3.

The author apparently realized that a new book should not be brought out on this subject unless there was some strong reason for so doing. Accordingly he proceeded at once, in his preface, to set forth that reason. Briefly, it lies in the publication of tables giving decimals of a degree in place of minutes and seconds. He argues that engineers will do well to adopt the decimal of the degree, abandoning the minute and second, just as they long ago adopted decimals of a foot and abandoned a whole family of units such as the inch, link, chain, etc. In figuring railway curves the computer gets his results in degrees and decimals of a degree. These must be converted to degrees and minutes before they can be set off on the regulation transit vernier. The author's tables, supplemented by similar reading verniers, will do away with these conversions from decimals of a degree to minutes and seconds. This saves time and decreases the chance of error. The author's argument is sound; bringing out this book he has performed a service which, in time, will be highly appreciated. So much for the outstanding feature of the book. Otherwise it is a very good railway field manual not radically different from numerous others.

Materials of Construction.—By G. B. Upton. John Wiley & Sons, Inc., New York. Cloth, 6x9 in.; 319 pp.; illustrated. $2.

This text book is restricted almost entirely to the theoretical discussion of the materials of construction. It is divided into two parts. The first part deals with the determination of the properties of the materials by means of engineering testing. The ordinary formulas for computing the stresses and deformations are examined, the assumptions on which they are based are stated, their range of validity is given, and the direction and magnitude of their errors after they cease to be valid are pointed out. No attempt has been made to give collections of data or the results of tests, but an attempt has been made to teach a student how to interpret and criticize test results.

The second part of the book treats of the nature of the internal structure of materials and of the control of properties through the control of the internal structure. This part of the book becomes a short study of theoretical and applied metallography.

The general analyses given for finding true stresses after the yield point in torsion and transverse loading is reached, and the detailed explanation of heat treatment from the standpoint of physical chemistry, are original. The form of presentation of the subject and its analytic treatment give the book distinct value as a text.

Railway Maintenance Engineering.—By William H. Sellew. D. Van Nostrand Co., New York City. Cloth, 5x7½ in.; 360 pp.; illustrated. $2.50.

This book is intended primarily for classroom use but contains considerable matter of a character sufficiently advanced to claim the attention of engineers in the maintenance of way departments of railways. There are 15 chapters on the following subjects: Engineering; Land; Grading; Bridges; Trestles and Culverts; Ties; Rails; Other Track Material; Ballast; Maintaining Track and Right of Way; Station and Roadway Buildings; Water Stations; Fuel Stations; Shops and Engine Houses; Icing Stations; and Signals and Interlockers.

The subtitle of the book is "with Notes on Construction." There are 194 illustrations and 6 folding plates. There are 21 tables on a great variety of subjects of direct utility to the maintenance engineer. There is a useful bibliography at the end of each chapter. The illustrations are especially well selected. They comprise photographs, pen and ink sketches and dimensioned line drawings. Every chapter is fully and appropriately illustrated.

The book is admirably adapted to classroom use, and will prove a handy reference work for the practicing engineer.

Inventions and Patents.—By Philip E. Edelman. D. Van Nostrand Co., New York. Cloth, 5x8 in.; 283 pp. $4.50.

The author states his intention to provide in this volume a text and reference book for "all persons interested in patents." His divisions of the subject are: Development of the Patent System; the Patent Office; Patent Attorneys; Genius of Invention; Fields of Invention; Preliminary Steps to Secure a Patent; Patentability and Practicability; Application for and Promotion of a Patent; Protecting an Invention; Points of Patent Procedure; Patent Rights and How They Are Utilized; Disposing of Patent Rights; About Infringements; Points about Foreign Patents; Thoughts on Inventions and Inventors; The Present Status of Inventions; Memoranda Appendix. The Appendix is some 70 pages and gives digests of decisions forms, charts, etc. Examination of the text indicates a fairly thorough treatise for the general reader; its careful reading gives the ordinary inventor about all he needs to know of procedure in securing patents and of transferring, protecting and developing patents. We recommend the book to anyone who has in mind the seeking of a patent.

Practical Surveying.—By Ernest McCullough. D. Van Nostrand Co., New York. Cloth; 5x7 in.; 395 pp.; illustrated; $2.

The book is intended to meet the needs of students whose mathematical preparation does not extend beyond the arithmetic given in the grade schools. It is also intended to serve as a text for self-tutored men who desire to become surveyors. The scope of the work is indicated by the eight chapter headings, which are: Introductory; Chain Surveying; Leveling; Compass Surveying; Trigonometry; Transit Surveying; Surveying Law and Practice; Engineering Surveying. In an appendix there are given the essentials of algebra. The author's practical knowledge of the difficulties of surveying is in evidence throughout the text. In his descriptions he has adopted a simple and rather unconventional style of expression, in an attempt to anticipate the difficulties of his reader. He has succeeded in his attempt to produce an elementary text on surveying which can be studied with profit by the man of limited education.

Safety Engineering Applied to Scaffolds.—By The Travelers' Insurance Co., Hartford, Conn. Cloth, 6x9 in.; 339 pp.; illustrated. $3.

The book is the first comprehensive treatment of scaffolds to be published in this country. Its scope and contents are indicated by its thirteen chapter headings, which are as follows: Reality of the Scaffold Hazard; Scaffolds Considered Generally; Bricklayers' Pole Scaffold—American Practice; Independent Pole Scaffold—American Practice; Lashed Scaffolds; Other Forms of Pole Scaffolds; Special Safety Features; General Features and Operations; Building with Horses; Suspended Scaffolds for Construction Work; Scaffolds of Other Kinds; Structures Similar to Scaffolds; and General Counsel.

The book is illustrated with line drawings and photographs of the various types of scaffolds and safety devices in use. Particular attention is given to American practice. The book will undoubtedly do much to raise the standard of scaffold building and usage in this country.

Masonry as Applied to Civil Engineering.—By F. Noel Taylor. D. Van Nostrand Co., New York. Cloth; 5½x8½ in.; 219 pp.; illustrated; $2.50.

This English work on masonry treats the subject from the viewpoint of utility rather than from its use for ornamentation. It is intended both for the use of students and those engaged in practicing civil engineering. It covers engineering works in stone and heavy concrete. The following chapter headings indicate the scope of the book: Stone Used in Construction Work; Labor on Stones and General Remarks on Masonry; Retaining Walls and Earth Pressures; Dock, Quay, River, Canal, and Sea Walls; Masonry Dams; Masonry Bridges; Masonry Towers and Pillars; Monolithic and Block Concrete Construction; and Shoring and Underpinning.

The book reflects English practice and is somewhat elementary. It contains little of direct interest to engineers in this country.

Surveying and Field Work.—By James Williamson. D. Van Nostrand Co., New York. Cloth; 5½x8½ in.; 355 pp.; illustrated; $3.

This is an English book intended for the use of students in technical schools and as a work of reference for surveyors, engineers and architects. It covers the principles of surveying and surveying practice in England. The first chapter treats of the fundamental principles of surveying, the six succeeding chapters cover chain surveying, and the eighth chapter considers the plotting of the plan. Succeeding chapters describe the construction and use of the compass, the sextant and the theodolite. The different types of levels are then described, followed by chapters on the use of the level on various kinds of work. The calculation of areas and earthwork quantities by various methods is then considered. The work closes with a chapter on the adjustment of instruments and one in which geometric and trigonometric formulas are given.

Reinforced Concrete Construction, Vol. III.—By George A. Hool, McGraw-Hill Book Co., Inc., New York. Cloth; 6x9 in.; 684 pp.; illustrated; $5.

This is the third of a four-volume treatise on reinforced concrete design and construction, this volume treating of bridges and arches. Volume I is devoted to fundamental principles and Volume II to retaining walls and buildings. It is the intention of the author to cover, in the fourth volume, structures not considered in those already published.

This volume was written primarily to meet the needs of students enrolled in the correspondence-study courses in reinforced concrete in the Extension Division of the University of Wisconsin, and the attempt has been made to omit intricate mathematical analyses involving the calculus, and to avoid mathematical sign language wherever possible. Both single-span and multiple-span arches on elastic piers are treated, two entirely different methods of arch analysis being presented in order that a check may be had on all arch computations. The work is copiously illustrated with photographs and line drawings of reinforced concrete arch constructions. The text is largely a compilation from numerous sources, and several chapters and articles have been contributed by experts in their respective fields. The book is divided into eight parts, the headings of which, indicating the scope, are as follows: Arch Bridges, 355 pp.; Slab and Girder Bridges, 59 pp.; Culverts, 36 pp.; Notes on Construction Plant, 26 pp.; Notes on Estimating, 13 pp.; The Artistic Design of Concrete Bridges, 35 pp.; The Construction in Detail of Several Types of Concrete Bridges, 77 pp.; and European Concrete Bridges, 76 pp. The book gives the most comprehensive and best treatment of reinforced concrete bridges in print.

Engineering and Contracting

Devoted to the Economics of Civil Engineering Design
and to Methods and Cost of Construction

EDITORS

H. P. Gillette C. S. Hill C. T. Murray S. C. Hadden C. W. Malcolm

Volume XLV. CHICAGO, ILL, JANUARY 26, 1916. Number 4

A NOTABLE COMBINATION OF OPPORTUNITIES FOR THE STUDY OF CONCRETE.

Within the week, Feb. 12 to 19, when the annual Cement Show will be held in Chicago, engineers and contractors are afforded a combination of opportunities rarely equalled for gathering information on concrete construction. Besides the Cement Show, with its exhibition of concrete workers' machinery and concrete products, there will be meetings, with extended programs of papers and committee reports, of three important concrete engineering associations. These are the American Concrete Institute, the National Conference on Concrete Road Building and the American Concrete Pipe Association. Each society has great strength of membership and of technical ability in its field. Each has a remarkably good program of subjects on which reports and papers will be presented. It should be the purpose of every engineer and contractor to attend these conventions. In so far as is practicable their several sessions have been scheduled so as to give those attending the widest opportunity to participate in all the proceedings. In so far as their permanent value and their direct interest warrant without undue exactions of space, the papers and reports will appear in issues of Engineering and Contracting following the conventions. Readers who cannot attend the conventions, and they will of necessity be many, will thus receive the service of the papers and discussions in as large measure as is practicable through the printed word.

ENGINEERING ADVERTISING AND SELLING BY MOTION PICTURES.

At several conventions of engineering societies, within the next few weeks, a feature of the program will be a motion picture show. These shows will be put on generally by manufacturers and will differ in subject but always they will tell the story of an engineering construction process. In this fact lies their value and, also, rests the reason for their mention here. The writer has observed construction operations of many kinds in many places and there is little novelty to him in seeing men and machinery in operation but had he never seen any of these things he would possess a very fair idea of several construction processes from the motion pictures of them that he has recently witnessed.

There is in the exhibition of motion pictures at conventions of engineering societies a valuable service. It is virtually impossible to visualize from a description the operation of a machine except in case of the man with rare imagination. To visualize the operation of a plant or a process of many operations is for most persons quite impossible. Who, for example, unfamiliar with mines and steel works can picture the character and sequence of operations required to produce a steel pipe or tube with any approach to precision working only from a description? Yet a motion picture exhibition which will be seen at several conventions soon to be held gives this precise visualization. The writer, who has been at the mines and in the steel works and has also seen the pictures, will attest the truth of this statement.

The purpose of these motion picture exhibitions at engineering conventions is advertising and selling. To the editor's mind it is one of the most forceful methods that has been devised. Most machines used in construction work are too large to be shipped around for the possible customer to inspect. It is absolutely impossible so to ship plants and processes. The motion picture film and projector can be shipped anywhere that a salesman can take his trunk. As a feature of engineering convention programs the well planned motion picture of construction plant and processes deserves every encouragement.

ONE REASON WHY ENGINEERS RULE AGAINST WINTER WORK.

The common practice of abandoning construction work with the approach of cold weather has been criticised in these columns. Facts and experience have been quoted in proof of the economic feasibility of prosecuting many kinds of construction in winter. There is, however, another side to the question and it is indicated in a recent ruling of the Iowa Highway Commission in regard to winter work on concrete road structures. Briefly, owing to failure of contractors to take proper precautions to safeguard concrete work done in freezing weather the Iowa Commission says: "The amount of worthless concrete which has had to be replaced to the serious detriment in durability and appearance of the structures, and the extent of the loss occasioned by freezing, has determined the Commission to set an arbitrary date this season for stopping all concrete work." There is little justification for frozen concrete in such structures as are required in ordinary highway work if the usual familiar precautions to prevent freezing are followed with care. The ruling of the Iowa Commission is therefore censure of carelessness rather than criticism of the practice of concreting in freezing weather. The contractor has much to gain by encouraging engineers and state bureaus controlling public works to practice a lenient attitude toward winter work. With assurance that all precautions will be taken to protect the work from dangers of cold the engineer will be willing to make concessions of material advantage to the contractor.

TEACHING THE PUBLIC THAT ENGINEERING WORK REQUIRES TIME.

Engineering work often suffers in quality because it is done in a hurry. Engineering works often cost more than they should because they are planned and built in haste. Of course the engineer knows these things but his employer does not. One of the greatest gains to be had from familiarizing the public with engineering procedure is the allotment of sufficient time for the proper planning and execution of engineering work. Engineers can do much to educate the public on this point and by so doing they will be well repaid for the effort required.

Non-technical city officials are notorious sinners in this respect. After calling for an engineer's report on a project, with a preliminary cost estimate, they wrangle over it for months, then, on deciding to go ahead, they telegraph the engineer to rush out his plans and specifications. These are oftentimes prepared in such haste that the engineer does well to get out a passably good plan—he must forego the critical examination of alternate plans from lack of time. Then if the season is far advanced, and it usually is before the engineer gets his cue, the various preliminaries preceding construction are rushed through as fast as the law allows. Every nerve is strained until construction is actually begun, then the official subsides and the engineer and contractor take advantage of this favorable relaxation of pressure to take stock of themselves and each other and the work in hand. The various points at which the work may suffer from all this haste need not be catalogued here. They are only too well known by our readers.

Lest it be supposed that we think only municipalities try the engineer's soul by imposing upon him alternate periods of partial or total idleness and frenzied haste, we shall also note briefly that officials of private business corporations often do the same thing. The editor has worked for three different railroads and on all of them did twelve months' work during the year. Sometimes the twelve months' work was done in nine months, sometimes in six but never at all uniformly throughout the full year. Of course the change of seasons has a bearing on this matter but the dilatory tactics of the officials is an almost equally strong cause for the fluctuations in the demand on the energies of the engineer. How many times toward the close of an easy day in the drafting room of a railway engineering department have we seen things put in an uproar by a belated order for some work to be turned out before the 4:43 pulled out of the station! The president and general manager were going out on that train with the chief engineer to look over a projected something or other. The something or other must be shown on the tracing of the line map and blue-prints must be made and colored and delivered to the chief before train time. Then the star draftsman was put on the pencil and ink work, the prints were made as fast as possible, dried over a radiator or blotted and fanned, and then colored. Again, the maintenance engineer is ordered to stake out a siding or an industry track the first thing the next morning and must take his instrument home with him at night in order to get on the job the next morning before the track gang gets there. Oftentimes the gang is held up an hour or more while stakes are being set.

The points mentioned with reference to railway work are small ones, admittedly, but they are characteristic. Not only are there violent and unnecessary fluctuations in the demands on the engineer from month to month but from hour to hour throughout the day. It all comes from the fact that the employers of the engineer do not realize that it requires measurable time to run lines and levels, to make drawings and cost estimates, etc. While slighted in many ways, particularly on railroads, the engineer is expected to perform his labors in short order on demand.

Not only does engineering work suffer from this belated haste, but the engineer suffers in more ways than one. He is unnecessarily subjected to extremes of enervating inactivity and of worrisome, nerve-racking work under pressure. And that isn't all by any means. This matter bears directly upon the unemployment problem among engineers. It leads to short engagements in which there are from ten to sixteen hours in the working day. The result is that the engineer works himself out of a job. If he does the work of nine months in six he is paid for six months and has the other three months left to look for another job. During the latter period, of course, he has no income. Here is a point well worth noting. An eight-hour day for engineers would lead to better engineering work, in many instances, and would mean longer engagements with income proportionately increased. The willingness of engineers to work early and late and at top speed encourages their employers to demand this of them as a right. Procrastination in telling engineers to go ahead with certain work is encouraged by the knowledge that as soon as the engineer gets the word he will begin his sprint.

Of course engineers do not fancy anything savoring of trade unionism. They do not believe in killing time or in restricting their output. But isn't it true that they would be acting to the best interests of themselves and their employers by insisting on a reasonably sufficient time in which to do engineering work?

THE PROGRESS REPORT OF THE SPECIAL COMMITTEE ON STEEL COLUMNS AND STRUTS.

The progress report of the special committee of the American Society of Civil Engineers, recently made in connection with the comprehensive series of steel column tests being conducted by that society and the American Railway Engineering Association in co-operation with the Bureau of Standards, contains some interesting data, a summary of which is presented elsewhere in this issue. In a previous report, made about a year ago, the committee reported that about 70 columns had been tested. During the past year the Bureau of Standards has tested 110 additional columns, which, with those previously reported, gives a total of 180 columns now available for study. These include various types of built-up sections as well as rolled H-sections; they also embrace three slenderness ratios, 50, 85 and 120 l/r. In planning the tests both light and heavy sections of each type were included, and in addition columns were included in which thin outstanding legs, square corners, and bulbs were respective features.

At present the committee's studies of the results of the tests have not progressed sufficiently to enable it to draw definite conclusions. Certain observations, however, may be mentioned. The results clearly show a falling off of the ultimate unit strength for the heavy sections when compared with the lighter ones, this holding true both for the built-up sections and for the rolled H-sections. A study of the test data for those sections having thin edges, square corners, and bulbs failed to disclose any considerable difference due to these factors. No attempt has been made to indicate a yield point for those columns with a slenderness ratio of 50 to 120 l/r. However, in some test columns cut from the longer columns after the latter had been tested, a yield point was very clearly indicated; these short columns had a slenderness ratio of 20 l/r. The tests thus far studied indicate that for the short columns the yield point is appreciably below the ultimate strength, but for the longer columns, in which bending action is shown, the yield point and ultimate strength are very close together.

This series of tests, when properly analyzed and interpreted, will undoubtedly prove a most important factor in placing the designing of steel columns on a rational basis. The wording of the report, however, makes it evident that the committee has not attempted to analyze thoroughly the data as the tests are being conducted. This is rather to be expected in that the committee is composed of ten very busy—although exceedingly well qualified—practicing engineers. The tendency to wait until the tests are practically completed before analyzing the data is, however, apt to result in the making of an unnecessary number of similar tests. Furthermore, it does not encourage changes from the original program of tests which might greatly enhance their value. Widespread discussion is particularly desirable, and the making public, from time to time, of full data on separate tests appears desirable, these data to be accompanied by such conclusions as the committee seems justified in making, as a basis for general discussion.

THE ELECTRIC STEEL INDUSTRY.

The growth of the electric steel industry in this and foreign countries has been remarkable. According to data published in The Iron Age there are at present 303 electric furnaces in operation or under contract, of which 73 are located in the United States and 8 in Canada. During the past year the greatest gain in the number of furnaces has been in the United States and Canada. Of a total of 90 furnaces installed during 1915, 32 are located in the United States and 8 in Canada.

In March, 1910, there were in operation or contracted for, in all countries, 114 furnaces; on July 1, 1913, there were 140; on Jan. 1, 1915, the number had increased to 213; and on Jan. 1, 1916, there were 303 electric furnaces. These furnaces represent a number of different types, the three most prominent of which are the Heroult, induction, and Rennerfelt. In this country the three types most used are the Heroult, with 40 furnaces, the

Snyder, with 12 furnaces, and the Wile, with 6 furnaces. Both the Heroult and the Snyder furnaces have made rapid strides during the past year, each about doubling the number of the previous year; the Wile furnaces entered the field only last year. The total yearly production of the 40 Heroult furnaces in the United States is placed at 1,470,350 tons, the average size of the furnaces in operation being 5.9 tons and of those contracted for 4.1 tons. The average daily capacity (24 hours) of the 12 Snyder furnaces is about 13 tons. The average size of the six Wile furnaces is about 1 ton, and their average daily capacity (24 hours) 12 tons. The largest size of Heroult furnace is 15 tons, the largest Snyder furnace has a daily capacity of 30 tons, and the largest size of Wile furnace is 1.5 ton, with a daily capacity of 15 tons.

At present the United States, with 73, has a greater number of electric furnaces in operation or under contract than any other country; Germany, with 53 furnaces, is second; England, with 46, is third; and Sweden, with 23, is fourth. One year ago Germany, with 46 furnaces, was first; United States, with 41, was second; Italy, with 22, was third; and Sweden, with 18, was fourth; at that time England had 16 furnaces, and at present Italy has the same number as one year ago, 22 furnaces. In 2½ years the world's electric steel industry has more than doubled, increasing from 140 to 303 furnaces; in the same period that of the United States has nearly quadrupled, the increase being from 19 to 73 furnaces.

"PROPER ENGINEERING SUPERVISION."

In reading in sequence perhaps half a score of Federal department reports on roads and drainage and irrigation the editor was attracted by a noticeable repetition. Every report began or concluded with a warning that for good results a prime essential was: "Proper engineering supervision." There is the suggestion for at least two thoughts in the persistent printing of this advice. First is the thought that experience of Federal department or bureau heads has proved to them the need of educating the public to the importance and need of engineers' services. Second is the thought that the practicing engineer is beholden to these Federal employees for much very powerful advertising in his behalf. We believe that both of these thoughts are worth a little consideration by engineers.

When not so very many years ago Federal and State bureaus began to be created to participate directly in engineering work many engineers met the innovation with direct opposition. Even now this antagonistic feeling prevails to a considerable extent. In part it comes from belief that work performed by these bureaus is business taken from the practicing engineer. In part also it comes from the contemptuous regard held by the "practical" constructor toward what he is pleased to consider the theoretical refinements of the professional. In the field of road construction in particular this reason is very strong. The editor has witnessed at more than one engineering convention in years past the set purpose of these "practical" workers in all discussion to bait the road bureau representative at every possible opportunity. On the whole, however, there has been a decided reversal of sentiment; the Federal or State engineering bureau representative is a considerably sought after participator in technical exposition and discussion. He has not only established conviction of his worth as a technical coworker but it is realized that his official work is creating instead of eliminating opportunities for employment for the practicing engineer.

One of the very great services rendered by Federal and State engineering bureaus has been the education of the public to greater belief in the need of the engineer's services. Instruction has been purveyed in many manners but one of them has been the reiteration in official reports of the phrase which is the title of these remarks. The argument that has gone with the phrase is well represented in kind by the article published last week on expert operation and maintenance of drainage pumping plants.

METHODS AND EQUIPMENT USED IN ERECTION OF HELL GATE ARCH OVER EAST RIVER, NEW YORK CITY.*

The connecting of the two outstanding halves of the Hell Gate arch span, on Sept. 30 and Oct. 1, 1915, marked the culmination of one of the boldest erection schemes on record. The arch span, which carries the New York Connecting R. R. over the east channel of the East River in New York City, is a part of the 2½ miles of bridge work extending from 138th St. in the Bronx to Lawrence St. in Astoria, Long Island. From the Bronx the bridge work crosses Bronx Kills to Randal's Island, then over Little Hell Gate to Ward's Island, and finally over Hell Gate to Astoria.

The arch span carries four railroad tracks between its trusses and two highway lines on brackets outside of the trusses. Between centers of skewbacks the span is 977 ft. 6 in., while between inside faces of the tower piers, at the coping, the span is 1,015 ft. The distance between centers of trusses is 60 ft. and that between outside railings 93 ft. The bottom of the floor system will clear the river at high tide by 135 ft., the center of the bottom chord by 265 ft., and the center of the top chord by 307 ft. 6 in. The arch is of the two-hinged type, and is divided into 23 panels of 42 ft. 6 in. each (see Fig. 1).

General Features of Erection Scheme.

It was necessary to use the cantilever method of erection as falsework could not be used, the river being 140 ft. deep in places and the boat traffic not only very dense but very unwieldly in the swift flood tides and swirling waters of Hell Gate.

The difficulties of erection were increased by the great weight and size of the arch members, the bottom chord sections at the skewbacks weighing 180 tons and at the center 85 tons. These members are 6 ft. 6 in. x 10 ft. 6 in. in cross section. The handling of such heavy members was without precedent, as 125 tons had been the maximum weight handled on previous work.

Guided by the fact that it was necessary to use the cantilever method of erection, and due to the excessive weights of members to be handled, the American Bridge Co. developed an erection scheme essentially as follows: A huge triangular structure was designed for each side of the river to support its half of the arch span until the two halves could be connected at the center and the entire span made self-supporting (see Fig. 1). The bottom of this structure rested partly on the tower pier and partly on the ground, and its rear end was held down by a large counterweight. From a point about half way up this structure a tension member connected it with the end of the top chord of the span. This supported the outstanding panels of the span until six of them were erected. A tension connection was then made from the top of the structure to the top chords at the end of the fifth panel, and this connection, which was termed the fore stay, held up the entire half spans. The other half of the structure was termed the back stay. At its top two 2,500-ton capacity hydraulic jacks were placed, one at each truss line. A saddle casting was placed on top of the plungers of the jacks and the eye-bar connection between the back stay and the fore stay was made by means of a 16-in. pin on top of this saddle casting. A movement of these jacks would thus raise or lower the saddle casting and in turn raise or lower the fore stay and the attached half arch span. The back stay was held down with a counterweight, making it immovable.

As these stays were only temporary structures they were designed with the chief object of using the permanent steelwork wherever possible, thus saving the expense of special material. Therefore the floorbeam hangers, track stringers and railings of the arch span were used, as they would not be erected until the span was self-supporting. The girder spans and the approach viaducts were also used, as the approaches were not to be erected until the arch span was completed. Extra ends were built on these pieces so that they could be spliced and joined together and later cut or burned off without changing the permanent number. In this way 15,425 tons of steelwork were used in the back and fore stays and in the counterweights, only 2,296 tons of which were special. Of the 13,129 tons of permanent steelwork in the stays 3,110 tons enter into the arch span and 10,019 tons into the viaduct approaches. This use of the permanent steelwork for the back and fore stays is an important feature of the erection scheme, and its economic value is apparent.

---

*Based on paper by Walter J. Parsons, Engineer in Charge of Erection of Hell Gate Arch, in The Wisconsin Engineer.

The views of Figs. 2 to 9, inclusive, show various stages of erection and illustrate the methods and erection equipment used.

Erection of Back and Fore Stays.

The erection of the Long Island back stay was started Sept. 1, 1914, and was completed for the first connection to the arch span by Jan. 1, 1915. The Ward's Island back stay was started in February and was completed for the first connection to the arch span by June 1, 1915, this back stay being delayed on account of the masonry tower pier not being completed on time.

Both back stays were erected in like manner: First a locomotive crane was landed on the dock from a lighter. This crane then erected an unloading derrick on the dock, and, after erecting the bottom chord of the back stay, set up a derrick at the counterweight end. The latter derrick in turn erected the counterweight bases and a tier of counterweight girders; it then set up the back stay traveler on top of this tier of girders. The latter erected the back stay ahead of it, climbing upon the portion it had erected. After it had erected the first connection for the arch span it set up the arch traveler on top of this connection; this traveler then rolled out to the end of the connection and erected the arch members, rolling ahead on the top chord.

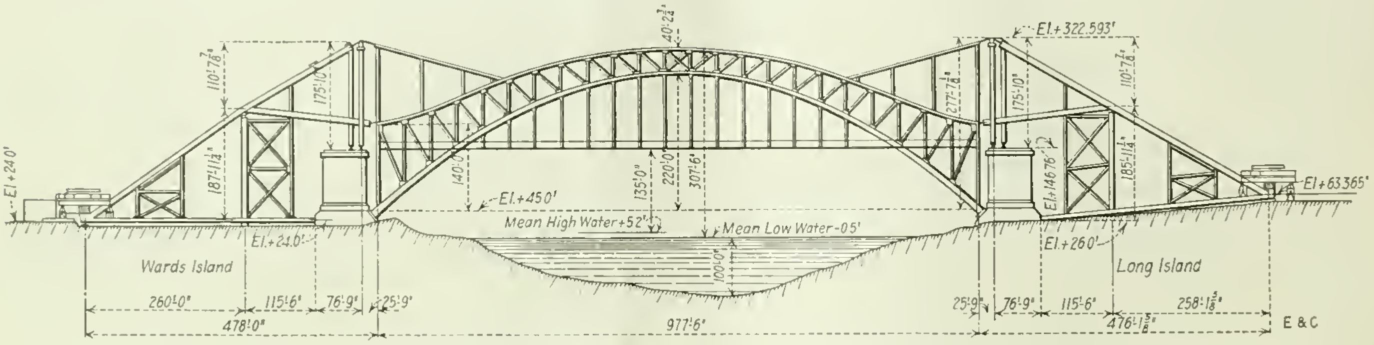


Fig. 1—General Elevation of Hell Gate Arch and of Fore and Back Stays Used in Its Erection.

Thus one outfit erected another, without extra moves and with ease and economy. The locomotive crane assisted with the erection of the back stay after it had erected its derricks; the rear derrick erected the remainder of the counterweight; and the back stay traveler erected the upper part of the back stay and the fore stay as soon as the arch traveler had moved out of the way. In this way each outfit paid for its cost of installation.

Erection of Arch Halves.

The erection of the Long Island half of the arch started Jan. 22, 1915, and continued until seven panels stood out over the river. Work was then stopped on this half and the men transferred to the Ward's Island side to hasten its erection. The latter half was started May 28, 1915, and on Aug. 30, when six panels were in place, the erection of the Long Island half was resumed and both halves were erected simultaneously until Sept. 30, when they joined at the center.

All panels were erected in like manner: First the bottom chords were erected and a large number of drift pins and bolts placed in their lower connections; this gave them sufficient strength so that these huge sections would stand out alone without sagging more than $\frac{1}{2}$ in. The diagonals were next erected and connected first at the top end and then to the outer end of the bottom chords. The sag of the bottom chord was then brought up at this last connection by means of drift pins. The posts were then erected and held up merely by drift pins and bolts in their bottom connections. The top chords were then erected, followed by the bottom laterals, top laterals and sway system.

Details of Travelers Used in Erecting Arches.

The travelers used in erecting the arch members are A-frame structures with telescoping rear legs to keep them level on the different slopes of the top chord of the arch span. They had booms 65 ft. long and were rigged with double topping lift tackle of 36 parts of $\frac{7}{8}$-in. wire rope, reaved on tandem blocks, and with a fall tackle of 26 parts of $\frac{7}{8}$-in. wire rope reaved on a one-piece top block and a five-part bottom block. This bottom block could have its center three sheaves, or its center nine sheaves, bolted to the top block, to make the tackle one of 20 parts, or of 8 parts of line. This tackle was changed to a lesser number of parts as the loads became lighter toward the center of the span, to gain speed in lifting and also to save length in the wire rope. The length of the wire rope on this main fall tackle is 7,000 ft. Both the topping lift and the main fall tackles are reaved from the center outward, and both ends of the wire rope are attached to drums on the hoist, thus making two lead lines for the main fall and four for the double topping lift.

The hoists which operate these tackles are all electrically driven, using direct current at 550 volts; those on the arch traveler are especially large and have 240-hp. motors. Each traveler has one two-drum and one four-drum hoist, with one drum of each fitted with a center partition to enable it to take up two head lines.

Placing Closing Panel of Arch.

On the morning of Sept. 30 eleven panels of the arch stood out over the river from each side, and everything was made ready to erect the center closing panel. The remaining distance between the ends of the bottom chords was measured, and an excess of $3\frac{1}{2}$ in. on the north truss and $3\frac{1}{8}$ in. on the south truss was found to exist with the temperature at about 62° F. The alignment taken showed that the Long Island half leaned to the north $2\frac{5}{8}$ in. and the Ward's Island half 5/16 in. in the same direction. The elevations showed that the Ward's Island half was lower than the Long Island half by $6\frac{3}{4}$ in. on the north truss and $4\frac{1}{4}$ in. on the south truss. As these differences in alignment and elevation were within connecting limits the center panel section was started up. By noon the temperature had risen from 62° to 80°F., and the opening had closed up nearly $1\frac{1}{2}$ in., although there still was space to work the member up through the dovetailing splice plates which were bolted onto the ends of the chords of the eleventh panel. The center panel members were bolted to the Long Island half of the span, and the opening between it and the Ward's Island half was left for the night.

The next day, Oct. 1, was a day of rain, with the temperature at about 62° F. The big jacks on top of the back stays were operated both up and down in order to bring the ends of the bottom chords in connection and contact. As one truss was lower than the other considerable jacking was required to correct the difference in elevation and to connect the trusses. The connection was finally made, however, and drift pins and bolts were placed at the center of the bottom chord panel points. As these panel points were intended to act as a hinge for a time the pins and bolts were kept within an 8-in. radius of the panel point center. A zero point was then marked on the plunger of each jack, opposite the zero on a scale at its side. The scales on the jacks on the Long Island side had units of 1 in., while those on the Ward's Island side had units of ⅞ in.; this because the Long Island half had the center panel attached to it and was therefore the longer. The order was then given to lower all jacks, evenly, according to the scales. A man watched each scale and reported the readings to the engineer in charge, who in turn reported them over the telephone to the foreman at the center of the bridge. The foreman was therefore able to decrease the speed of one side, or to increase that of the other, and thus prevent a load being thrown from one half to the other. The plungers of the jacks were lowered a total of 16⅜ in. on the Ward's Island side and 19¼ in. on the Long Island side, or until the pressure gage registered zero and the connections of the fore stay to the arch were loose. The hydraulic pressure on the

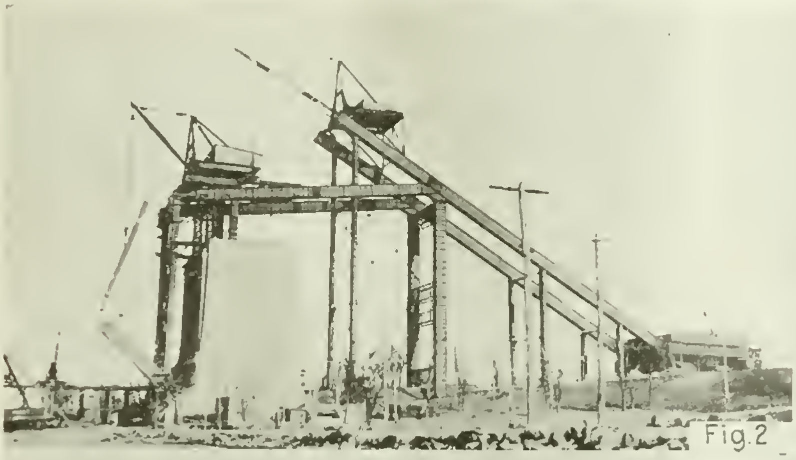


Fig.2

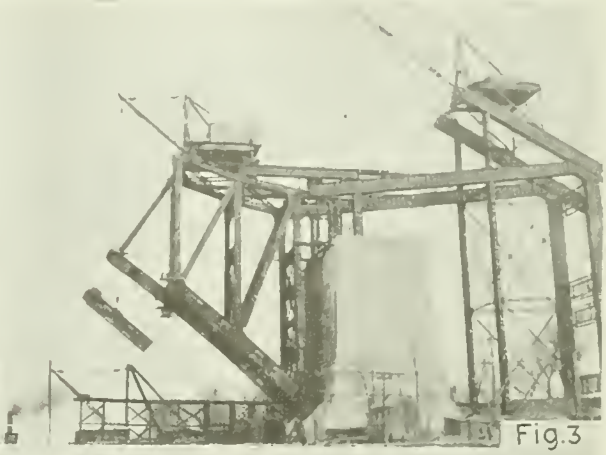


Fig.3

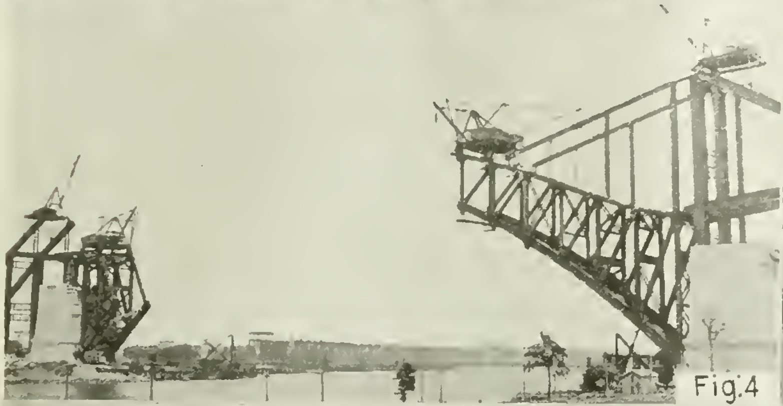


Fig.4

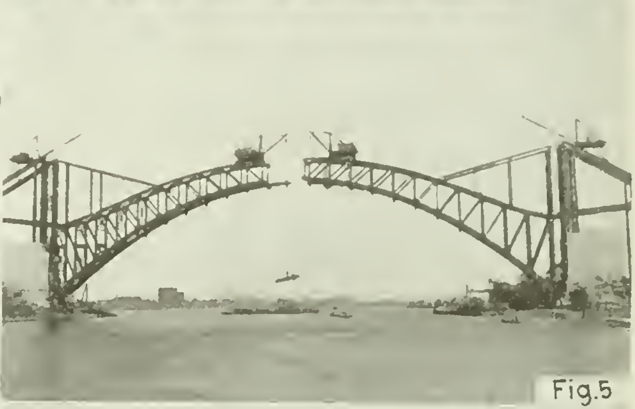


Fig.5

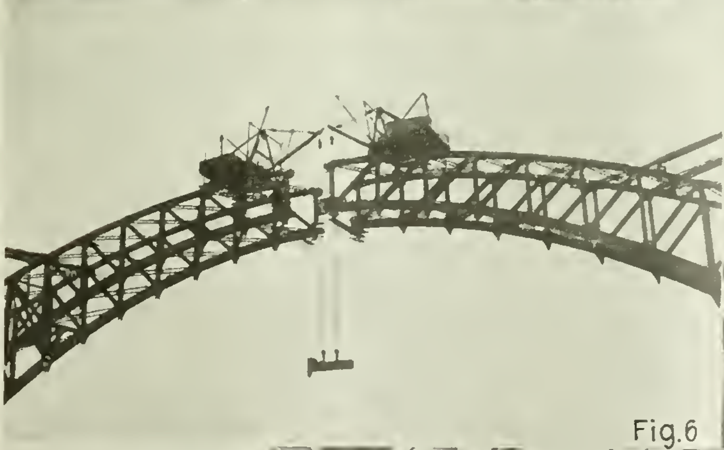


Fig.6

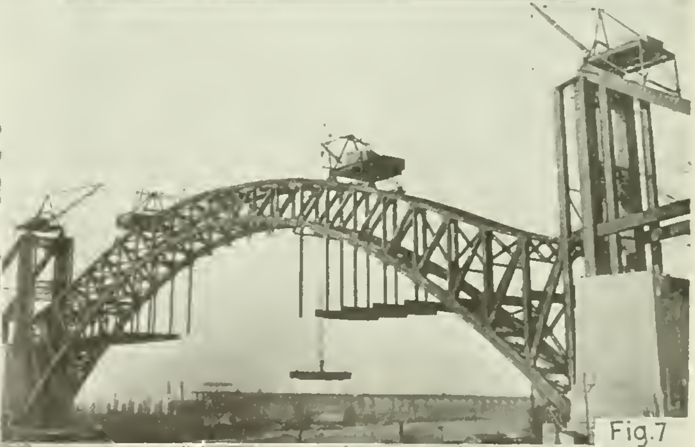


Fig.7

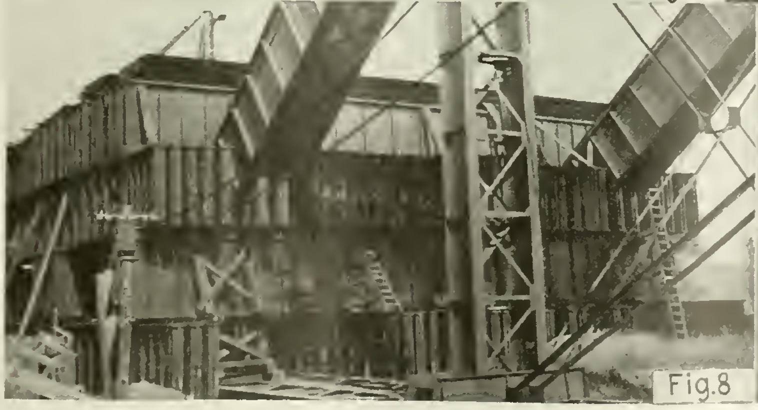


Fig.8

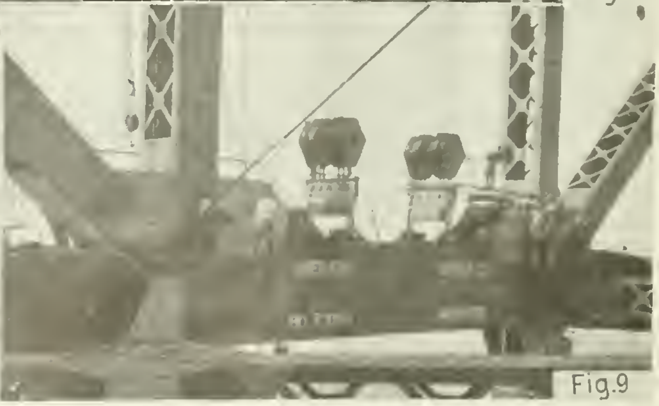


Fig.9

FIGS. 2-9—VIEWS ILLUSTRATING METHODS AND PROCEDURE USED IN ERECTING HELL GATE ARCH.

Fig. 2—Back Stay Nearly Erected—Starting Erection of Arch Span. Fig. 3—Erecting Third Panel of Arch Span. Fig. 4—Erection of Arch Span Proceeding from Both Ends—Note Fore Stay in Place. Fig. 5—Arch Halves Nearly Completed. Fig. 6—Placing Closing Panel of Arch Span. Fig. 7—Arch Completed—Derricks Placing Floorbeam Hangers and Floorbeams. Fig. 8—Floorbeams of Arch Span Piled to Form Anchorage for Back Stay. Fig. 9—Placing 80-Ton Lower Chord Member in Center Panel of Arch Span.

Ward's Island plungers at the start was 3,900 lb. per square inch on their 39-in. diameter surface, and 4,100 lb. per square inch on the Long Island side. The total time of lowering was about 1¼ hour, and at all times the readings of the four jacks were within ¼ in. of each other.

Levels were taken continually during the lowering at the counterweights to insure that their released weight did not cause too much settlement of the foundations, and thus cancel the lowering at the center. The 5,091 tons of counterweight had not acted on the grillage foundations up to this time and the action of this weight was therefore in question. The Long Island counterweight settled 2½ in. and that at Ward's Island ⅞ in., these settlements also being reported to the foreman at the center of the span.

An open line telephone system was maintained between the center of the arch, the two jack platforms on top of the back stays, the two counterweights of the back stays, and the field office. At each place a man was on constant duty, and he was able to hear all reports and orders given. In addition, the head officials, who were in the field office, also were kept fully informed as to progress. With the plans and laid-out schedule before them they were in position to correct immediately any unforeseen deviation from this schedule.

The center members of the top chords were not placed in position until Oct. 4, as rainy days intervened. The top chord pieces had been made about 2 in. shorter than their computed length to provide for any miscalculation as to actual length when the bottom chord was stressed, it being the intention to insert filler blocks in this space after the full dead load was acting. When the top chords were placed the openings were found to be 2⅝ in. at the north truss and 2½ in. at the south one; the calculated distance for this condition and temperature was 2½ in.

The top chord pieces were connected at their Long Island end only and were left loose at the other end, as the span is to act as a three-hinged arch until the full dead load is acting. Rivet holes will then be drilled in the blank (without holes) Ward's Island ends of these top chords to match those in the splice plates, and rivets then driven. The bottom chords will be fully riveted at this temporary center hinge, thus making the span a two-hinged arch—one hinge at each skewback.

After the arch was closed the floorbeam hangers were taken down from the fore stays and hung with their floorbeams in their permanent positions. The back stays are being taken down, and, as soon as the arch stringers and railings are released, they will be set in place, at which time the span will be completely erected and ready for riveting. The girder viaduct approaches will then be erected from the far ends toward the arch span, and, as soon as the six concrete piers on each side are constructed at the present positions of the back stays and the girder spans erected on them, the bridge company's work will be completed.

Personnel.—The Hell Gate arch and approaches were designed by Gustav Lindenthal, consulting engineer, for the New York Connecting R. R. The steelwork was fabricated and is being erected by the American Bridge Co. The scheme of erection was developed by the bridge company under the direction of Emil Larsson, assistant chief engineer.

CONSIDERATION OF MERITS OF SERIAL BOND PLAN AT BUCYRUS, OHIO.

The question of abandoning the present policy of issuing long-term bonds in favor of short-term serial issues will probably be taken up by the new city administration of Bucyrus, Ohio, says The Bond Buyer. The suggestion follows a movement that has been widely discussed within the last few months in various sections of the country in relation to the issuance of bonds for municipal improvements. There appears to be a well-defined sentiment on the part of local investment brokers that the short-term bonds would meet a more ready market, but argument against this claim is made on the ground that the present market for bonds is abnormal; the demand for bonds with maturities not far distant is more active just now than for some time. Representatives of some financial institutions assert that a saving will accrue to the city by issuing only serial bonds instead of long-term bonds to be redeemed in full at maturity. Others admit that as a mathematical proposition there would be no economy to the public. Their greatest opposition develops on the score that it is bad policy to issue bonds with a 25 or 50 year maturity for improvements that will have been worn out before the bonds are taken up. Fear that interest rates will go up and premiums down if bonds are put out on the serial plan has been expressed by those favoring the long-term issues.

METHOD OF MARKING PAVING BRICK FOR IDENTIFICATION IN MAKING RATTLER TESTS.

To the Editors:—I have read with interest the article on "Method of Marking Paving Bricks for Identification in Making Rattler Tests," which appeared in the Dec. 22 issue of Engineering and Contracting.

I wish to call your attention to the system, Fig. 1, of marking paving bricks for identification which has been used for more than two years in practical work by the laboratory of the Illinois State Highway Department:

The bricks are marked with a compressed air drill making a hole only 1/10 in. in diameter, and ¼ in. deep. This scheme of marking would appear to have an advantage over the method proposed by Mr. C. A. Baughman, in the "Iowa Engineer," in that the marks are so small that the losses of the bricks in the rattler are not materially increased.

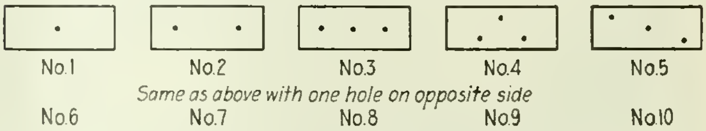


Fig. 1—Marking Paving Brick for Rattler Test.

Approximately 200 rattler tests have been performed during the past years, using the above scheme of identification, and it has been noted that very few of the bricks which broke, or chipped, in the rattler, were broken through a drill hole.

A number of comparative rattler tests were performed with marked and unmarked bricks, and it has been found that the drilling of the small holes used in marking did not cause any appreciable increase in the rattler loss.

It has been noted in practice that a shipment of bricks showing a fairly high average rattler loss and uniform wearing qualities, will often make a better pavement than bricks showing a low average loss, but also rather wide variations in wearing qualities. It would, therefore, appear that in all rattler tests the loss of each individual brick should be measured, and that specifications should be made such as to permit the use of bricks showing a fairly high average rattler loss, and exceptionally uniform wearing qualities, and as to require a lower average rattler loss for bricks showing less uniformity.

Very truly yours,
F. L. Roman, Testing Engineer.

Springfield, Ill., Jan. 3, 1916.

METHOD, COST AND RESULTS OF TESTING NEW WATER MAINS AT HARTFORD, CONN.*

By Caleb Mills Saville, Chief Engineer, Board of Water Supply, Hartford, Conn.

During the past three months opportunity has been had to test ten sections of main pipe aggregating nearly two miles in length. This pipe was laid in city streets by the regular maintenance force of the department. The results are given in Table I. No definite criterion was set for this work but the results obtained last year from testing 7½ miles of 42-in. cast iron pipe of the Nepaug supply main were kept in mind. On the basis of nominal diameters the leakage from this line under test pressure varying from 100 to 125 lb. per square inch was at an

---

*From a paper read before the New England Water Works Association.

TABLE I.—DATA FROM TESTS OF WATER DISTRIBUTION MAINS AT HARTFORD, CONN.

Location.	Date (1915).	Size of main, in.	Length, feet.	Joints on main pipe.	Lin. ft. joint.	Test pressure, lbs. per sq. in.	‡	
							Total.	Lin. ft. of joint.
New Britain Ave.	Oct. 29	10	620	54	148[1]	126	140	0.947
Arnoldale Road..	Sep. 14	20	2,325	194	1,017	93	130	0.128
New Britain Ave.	Sep. 14	12	1,197	102	320	106	98	0.206
Asylum St........	Sep. 30	12	1,327	115	399[2]	119	432	1.080[9]
Asylum St........	Oct. 16	12	1,070	99	341[3]	125	582*	1.700[10]
Seymour St......	Sep. 30	8	1,159	101	224[4]	109	194	0.867
New Britain Ave.	Nov. 12	12	1,054	91	309[5]	125	97	0.313
Allen Place.......	Nov. 11	8	550	50	113[6]	120	75	0.670
Allen Place.......	Nov. 5	8	1,076	93	206[7]	120	376†	1.820
Jefferson St......	Nov. 27	8	562	49	109[8]	105	162	1.435
			10,940=2.07 mi.		3,077		2,286	0.717

*Ordinary pressure here is 65 lb., leakage at this pressure 27 gal. per 24 hrs. †Large amount probably duc to corporation cocks not entirely closed. [1]Includes 4 6-in. joints. [2]Includes 10 8-in. joints. [3]Includes 4 8-in. and 14 6-in. joints. [4]Includes 8 6-in. joints. [5]Includes 15 6-in. joints. [6]Includes 4 6-in. and 2 4-in. joints. [7]Includes 6 6-in. and 2 4-in. joints. [8]Includes 4 6-in. joints. [9]Includes some leakage at an 8-in. connecting gate. [10]Includes some leakage from an 8-in. gate. ‡Leakage per 24 hours, gallons.

average rate of 0.695 gal. per 24 hours per linear foot of pipe joint. It is considerable of a coincidence that the average leakage per linear foot of pipe joint for 24 hours given for the ten sections of distribution pipe tabulated herewith is also practically the same.

In the specifications for the construction of the Nepaug pipe line the section concerning testing read in part, "The pipe shall be tested under a static pressure corresponding to a water level everywhere of at least 100 ft. above the hydraulic grade line shown on the contract drawings. The entire leakage of any section shall not exceed a rate of 2 gal. in 24 hours per linear foot of pipe joint, the length of joint to be figured on the nominal interior diameter of the pipe." The amount here given was decided upon only after careful consideration of the results of tests elsewhere and the intention was to set such a limit that, on the one hand excessive joint leakage would be guarded against, and on the other the cost of the work would not be increased considerably by too severe requirements. Observations of working conditions, experience in testing and the results obtained from the tests showed that the leakage allowable might well have been set at least one-half the limits given without calling for any special precaution or unusual care on the part of the contractor.

Mr. E. G. Bradbury, of Columbus, Ohio, proposed as a standard for allowable leakage in cast-iron water pipes an average of 100 gal. per inch mile, equivalent to about 0.8 gal. per foot of lead joint for each complete contract or district with a maximum of double this for any single test. The testing of pipes discussed in this paper shows that the proposition of Mr. Bradbury would set requirements well within the results which were obtained.

In the tabulation results are given in terms of linear foot of pipe joint which seems to be the most logical unit. Nominally, pipe joints are 12 ft. apart, practically they are seldom or never this distance. For example, on the 7½ miles of 42-in. pipe the average laying length between joints was 11.75 ft. On the section of distribution pipe given in Table I the laying length has varied from 10.8 ft. to 12 ft. If there are many specials or cut pipe, the laying length may be reduced considerably below that given above. As the unit—"inch diameter per mile of pipe"—must be reduced from the length of pipe joints actually exposed to leakage, the actual number of joints makes considerable difference in the result. Besides this, in most every line there are branches and connections having various sized joints differing from those on the main line. These must be considered in getting a unit for expressing leakage. All of these conditions readily fall in with "leakage per linear foot of joint" and for this reason that unit is considered to be well adapted for the purpose of comparing leakage for different pipe lines.

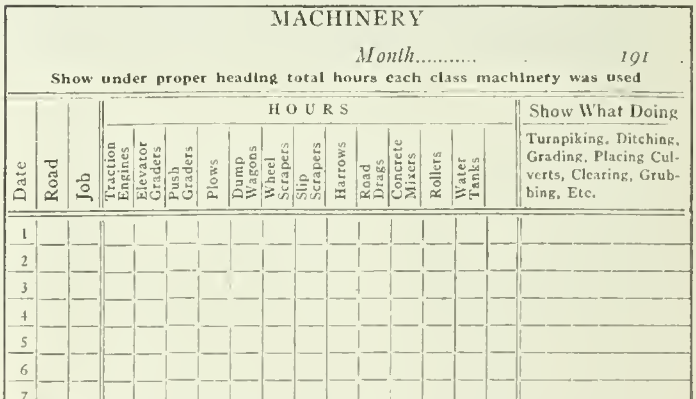
In running tests on distribution main sections between gates are ordinarily taken. The intention is to apply about 40 lb. pressure to the section under test in excess of that ordinarily expected. Wherever possible the section is subjected to several different pressure heads during the test with the intention of obtaining data as to the character of the leakage. While the information is not yet complete the indication is that with no gates or corporations open or joints blown out, the loss of water as might be expected with thin openings varies nearly directly with the pressure. With this in mind it is possible to make very reliable deductions as to the kind of leak to look for when an excessive draft is shown in the test.

Apparatus.—The apparatus used in testing is the ordinary force pump for cleaning obstructions from service pipes. Usually the pump is a single cylinder, hand operated force pump, 2-in. diameter piston and 4-in. stroke operating from a small tub. The capacity of this pump under 100 lb. pressure has been found to be about 2 gal. per minute. The quantity passing the pump is measured by an ordinary meter of small size. The cost of testing including all labor, material and supervision has averaged about $6 per test. On the Nepaug pipe line where conditions were somewhat different, the cost of the work was about 4 ct. per linear foot of pipe or $200 per section tested. In this case a steam pump was necessary to fill the pipe and the cost included the setting up and operation of this plant and oftentimes also the laying of long lines of small size pipe.

FORM FOR RECORDING THE TIME OF MACHINERY IN ROAD WORK.*

By O. H. Mann.

On all work involving the use of machinery or equipment it is not only desirable that some record be kept of the actual working time of the machines on each job, but it is absolutely necessary if the engineer is to know the actual cost of such work. In a great many instances a yearly depreciation is established and this deprecia-



MACHINERY

Month.......... 191 .

Show under proper heading total hours each class machinery was used

			HOURS													Show What Doing
Date	Road	Job	Traction Engines	Elevator Graders	Push Graders	Plows	Dump Wagons	Wheel Scrapers	Slip Scrapers	Harrows	Road Drags	Concrete Mixers	Rollers	Water Tanks		Turnpiking, Ditching, Grading, Placing Culverts, Clearing, Grubbing, Etc.
1																
2																
3																
4																
5																
6																
7																
8																
9																
10																
11																
12																
13																
14																
15																
16																
17																
18																
19																
20																
21																
22																
23																
24																
25																
26																
27																
28																
29																
30																
31																
Total Hours																

Fig. 1—Form for Recording Time for Machinery.

---

*Extract from a paper read before the Minnesota Surveyors' and Engineers' Society.

tion is pro-rated to the various jobs on which such machinery is used, and providing the machinery is used continuously, is oftentimes near the correct amount which should be charged, but a little thought upon the part of the engineer can devise a plan or form upon which the actual record of the work done by the machine can be kept and the yearly depreciation divided upon a basis of this record will give the actual cost of the machine work and not only aid the engineer in making up future estimates, but will give an accurate comparison of one certain class of machinery as against a similar class engaged upon like work. The form shown by Fig. 1 has been designed with a view to arriving at the amount of depreciation of road machinery charged to each different job. It was used on road work in Clay County, Minnesota, in 1915.

ENGINEERING AND ECONOMIC FEATURES OF THE IRRIGATION SYSTEM OF THE LOS ANGELES AQUEDUCT—CONSTRUCTION JUST BEGINNING.

Contributed by Burt A. Heinly, Secretary to William Mulholland, Chief Engineer, Bureau of Water Works and Supply, Los Angeles, Calif.

With the award of contract Jan. 10, 1916, for 4,000 tons of riveted sheet steel pipe involving a cost of $269,480 and the present preparation of specifications for an additional 5,000 tons of pipe for which bids will soon be asked, Los Angeles has officially begun the installation of the extensive irrigation distribution system at the outlet of the Los Angeles Aqueduct. Installation of the water mains will commence within the next 30 days and will be rushed as rapidly as conditions will permit in order to place under irrigation the broadest possible area for the summer of 1916. With the issuance of additional specifications in series the work will be continued until the whole system, involving an expenditure of over $4,000,000 is installed.

The project is of such magnitude that it is second in importance only to the construction of the Los Angeles Aqueduct. It comprises, in addition to some miles of concrete trunk conduits, a system of 317 miles of steel pipe lines and is unique in that the irrigation supply will be furnished under pressure the same as for domestic use and on a scale that exceeds many of the reclamation projects of the Federal government.

Before entering upon a detailed description of the plans and the proposed methods of construction it will be well briefly to describe the source of the supply and the causes which have led the city of Los Angeles to embark upon a commercial enterprise of such scale.

The Los Angeles Aqueduct comprises a system of concrete conduits, tunnels, inverted steel siphons and reservoirs by which the collected flow of the eastern face of the Sierra Nevadas is brought a total distance of 231 miles across the Mojave desert and under high mountain ranges to the rim of the San Fernando Valley, 27 miles northwest from the Los Angeles city hall. The distance to be traversed and the engineering difficulties to be overcome, together with the long future needs of the municipality, which lies in a semi-arid region, made it imperative that the capacity of the watercourse should be limited only by the quantity of the supply and the ability of the city to finance the project. As designed and built the aqueduct has a net delivery of 260,000,000 gal. per day at its outlet, which with the system of regulating and storage reservoirs and the Owens Valley artesian field (owned by the city, tested and capable of development if need arises), can be depended upon for this quantity 365 days in the year.

Los Angeles has obtained in the past, and will continue, its domestic supply from the Los Angeles River which can be depended upon for about 60,000,000 gals. daily. In addition to this quantity Los Angeles during the past summer required about 16,000 gal. daily from its aqueduct supply. Next summer, because of the recent acquisition of 14 private companies by the municipal works, this will be increased to 25,000,000 gal. per day or less than 10 per cent of the aqueduct's rated flow. It will be seen that there is thus at the present time a very large surplus to be held in abeyance of the city's domestic needs for a period estimated at from 50 to 75 years hence. This surplus must be put to work not only to assist in carrying the very heavy tax burden of $26,000,000, which all aqueduct water works construction has imposed, but, what is even more important, to preserve the city's rights under the law to the flow of the many streams upon which the city has filed and claims ownership.

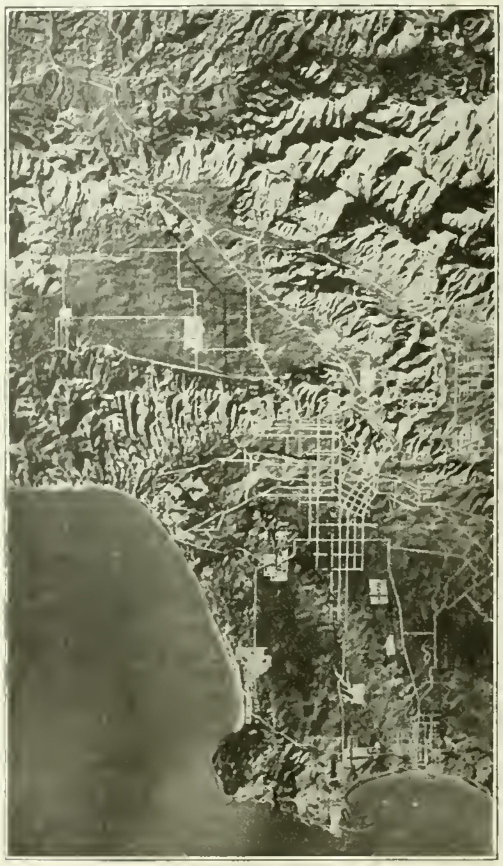


Fig. 1—Greatly Reduced Photograph of Relief Map of City of Los Angeles, Including Recently Annexed San Fernando Valley, at Left Center.

Contiguous to Los Angeles are large areas of land very fertile, but undeveloped because of the semi-arid conditions. One of these areas of over 103,000 acres comprising the San Fernando Valley, until the spring of 1915 was an unincorporated district between the city limits and the mouth of the aqueduct. For the privilege of using aqueduct water for irrigation and domestic needs the city made the demand that the area should form itself into a district or districts and vote bonds to provide a distribution system which would be built and operated by the city as a part of its municipal system. Thereupon the city, with the consent of the voters of the valley, proceeded to annex the entire 103,000 acres, making Los Angeles in area about equal to that of Greater New York. By this action, the area in addition to building its own distribution system, pays its share of the aqueduct bonds and Los Angeles is able to protect the sanitary features of the aqueduct from the collection works to the tap of the consumer. With this brief explanation the reader will gain some idea of the involved mass of national, state and municipal legislation that had to be enacted, the education of Los Angeles and San Fernando voters that was made necessary, and the large amount of field and office engineering studies that have been under way for a period of seven years and which are only now becoming realized.

The San Fernando Valley as annexed to Los Angeles comprises 103,000 acres, of which 87,211 acres are under the aqueduct system. The location of the valley is shown in Fig. 1. Of the 87,211 acres, about 300 acres are hill sections where pumping will be required; the remainder will be supplied entirely by gravity flow. Two irrigation districts are included within the 87,211 acres;

one of these, the San Fernando, of 76,080 acres, has organized, voted bonds for $2,606,000, bids for which were opened Jan. 10 and upon which construction is now being entered; the other, called the Mission, of 11,131 acres, will vote upon the issuance of $380,000 worth of bonds some time in February. While separate political entities, they comprise a single district so far as the engineering plans have been worked out, and in the following it is so described.

The valley, surrounded by mountains of considerable height, is bowl shaped, with an elevation at its eastern end of 500 ft. above sea level, running by gentle gradient to 950 ft. at its western end, and tips to the southwest in the direction of Los Angeles city. It has a drainage area of 503 square miles and provides the flow of the Los Angeles River. The surface and the subterranean rights to even this inadequate irrigation supply were found in a very famous water suit to be vested in Los Angeles for her domestic needs so that the valley without a water supply of any kind, until the aqueduct source was assured, has remained in almost the same uninhabited condition that the Mission padres found it over a century ago. The soil is of a rich alluvial sandy loam in the eastern part of the valley, merging into an adobe in the western valley end. With almost the same climate as Los Angeles, the foothill region is now being planted to orange and lemon trees. The bottom lands will go into alfalfa, beans, sugar beets and truck gardens. The property valuation of the area at the present time is about $22,000,000.

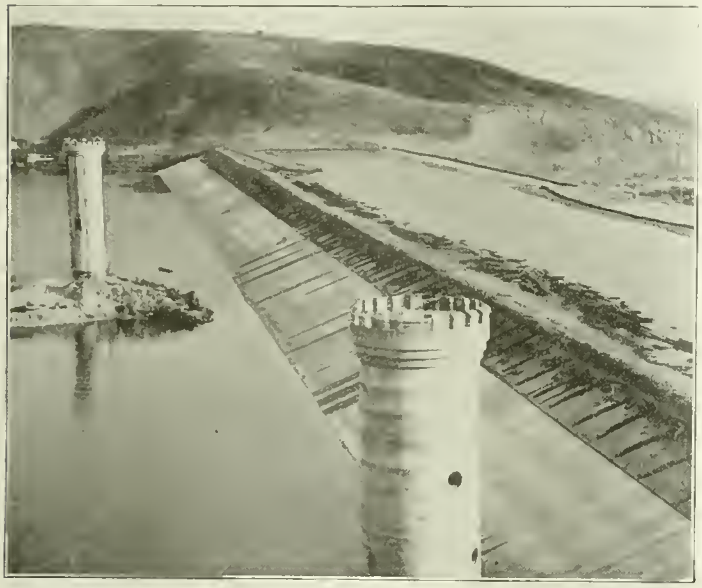


Fig. 2—Lower San Fernando Reservoir at the Outlet of the Los Angeles Aqueduct, Showing Dam in Process of Construction by Sluicing.

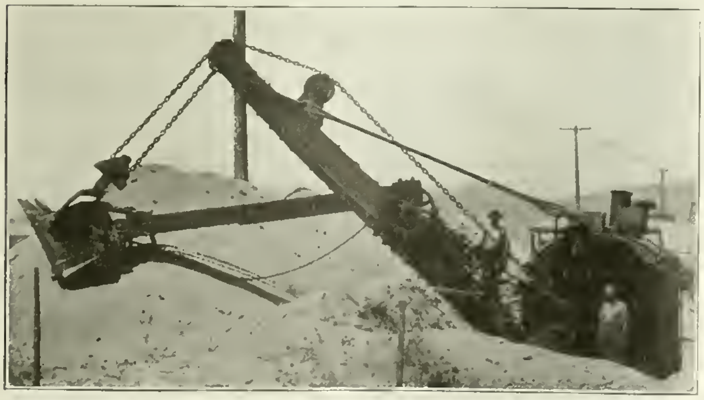


Fig. 3—Type of Special Long-Boom Marion Steam Shovel Found Peculiarly Adapted for Trenching for Large Irrigation Trunk Pipe Lines.

To care properly for the irrigation of the district, about 8 miles of gravity closed concrete conduits and 317 miles of riveted sheet steel mains are required. The total tonnage amounts to 25,719 tons, the first contract thus representing about one-sixth of the total necessary to purchase and a length of 35 miles.

The aqueduct pierces the Sierra Madre Range on the north side of the valley about midway between its eastern and western limits. From the aqueduct outlet elevation of 1,461 ft. above sea level, a concrete tunnel and conduit line leads easterly along the foothills (work on which is now being started) to supply an area of 8,960 acres, which comprises a district of itself on account of the higher elevation of the region.

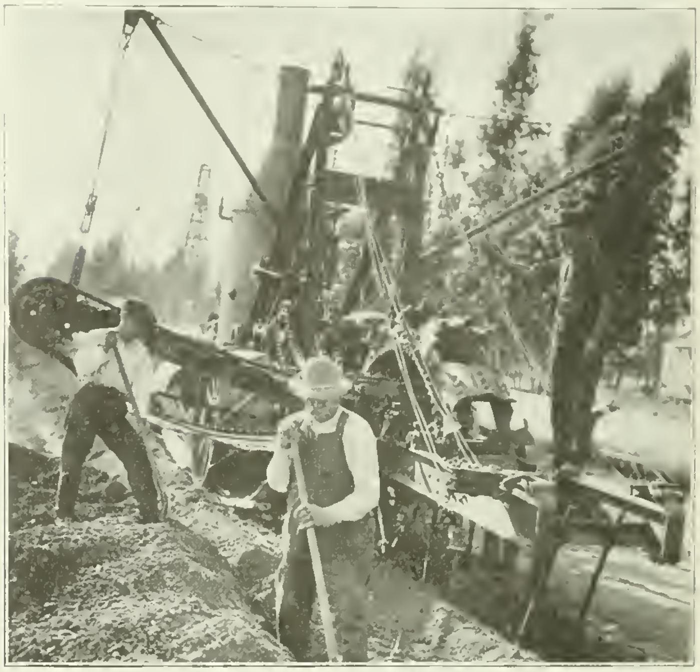


Fig. 4—Buckeye Trench Excavator Employed in Laying 8 to 16-In. Irrigation Pipe Laterals.

One and one-half miles below the aqueduct outlet, the second concrete conduit and steel pipe supply line branches from the City Trunk line, fully described in Engineering and Contracting of May 6, 1915, at an elevation of 1,150 ft. and continues southwesterly for a distance of 10.3 miles to empty into the proposed Chatsworth reservoir. This basin, upon which work is yet to be undertaken, will have a capacity of 25,000 acre-feet and a high water elevation of 910 ft. above sea level. From this reservoir to be formed by the building of three dams with a total content of 1,931,000 cu. yd., the floor of the valley will be watered. On the south side of the valley the gravity delivery will go to 1,000 ft. elevation in the southwest corner, tapering to 850 ft. in the southeast corner of the valley. The Chatsworth conduit and reservoir have a twofold purpose in that they provide for the storage of winter flow and peak flow during the daily intervals when the aqueduct power plants are under operation. Moreover the Chatsworth conduit by a large 45-in. diameter main will deliver to higher elevations in the southwest corner of the valley than is possible from the Chatsworth reservoir and to lower elevations as well when it is desired, from any reason, to cut the reservoir out of service temporarily.

Two miles below the aqueduct outlet and connected to it by the concrete portion of the City Trunk line is San Fernando Reservoir No. 2 which acts for storage in power development, regulation and storage for irrigation and as a reserve for Los Angeles domestic needs should some force of nature seriously rupture the long line of aqueduct to the north. This reservoir when completed will have a capacity of 23,000 acre-feet. It is formed by the building of a dam 2,060 ft. long, 140 ft. high, 750 ft. wide at the base and 50 ft. at the crest, with a content of 2,675,000 cu. yd. Work has been under way on this dam for five years. It is being built by the hydraulic fill process, as shown in Fig. 2, the aqueduct flow since 1913 having been used, and on Jan. 1, 1916, had been raised to a height of 95 ft. with a content of

2,180,000 cu. yd. During the last spring and summer, work was temporarily discontinued so that the reservoir might be utilized for irrigation uses to such territory as could be reached by temporary makeshift ditches. Between this reservoir and the aqueduct outlet a site for a second storage reservoir of 15,000 acre-feet has been purchased and this will be constructed ultimately to complete the aqueduct distribution reservoir storage system as above described.

From the Lower San Fernando Reservoir runs the San Fernando main, a sheet steel line 54 in. at its inlet, tapering to 30 in. at its junction with other trunk lines. This is one of the lines included in the first contract for steel.

Tapping the aqueduct outlet direct as well as the San Fernando Reservoir is the City Trunk line running easterly then south to traverse the district at its easterly end and carrying the city's domestic needs. This line has an initial capacity of 11,500 miner's inches at its inlet, ranges from 72 to 54 in. in diameter and was fully described in Engineering and Contracting of May 6, 1915. It is the only line fully installed and in operation at this time.

Through the middle of the valley from east to west runs a large supply main from the Chatsworth reservoir, commencing with 56-in. diameter pipe and tapering to 30-in. diameter, by which that reservoir supplies the whole bottom area of the valley and which is tied into all the other trunk supply mains. From this description it will be seen that a great deal of engineering study has been employed to lay out the system in such a correlated manner that every part of the valley is assured of an uninterrupted supply even if the storage basin or conduit from which it ordinarily receives service has been thrown out of commission. In some cases there are three circuits possible. The idea has also been kept in mind by tying in a number of the smaller laterals.

The system is being installed on the basis of supplying 1 miner's inch continuous flow to every 5 acres. This is equivalent to 1 in. to 7½ acres for an irrigation season of 240 days and is the allotment required in ordinary irrigation practice in this region.

It should be kept constantly in mind that the supply is surplus domestic water being used as a waste product for irrigation and that Los Angeles looks forward to the day when the whole aqueduct flow will be required for domestic use. The question that will be asked immediately is "what disposition will be made of the system now being installed, how can the water be withdrawn from the land where it is now being applied and what will become of the population dependent upon the water, for none is elsewhere obtainable?"

To this question the answer can be made that a very broad study of water usage as anticipated in Los Angeles for at least 50 years has been made. From consumption records of the city system it is shown that for the domestic needs of an acre of the usual California homes, 2,600 gal. daily is required. This is the equivalent of 1 in. to 5 acres. In other words the quantity required to irrigate one acre of citrus trees is the same as that required for the same acre built up in homes.

Los Angeles has defined her city limits, she has provided in her city charter that no water shall be sold outside those limits unless upon a two-thirds majority vote of the citizens and by fixing her boundaries she is perhaps attempting what no other American city has before attempted in that she is definitely undertaking to guide and establish her growth of population where she is best able to care for it. As population increases within this new area which the city intends shall be the outlet for her growth, and as with growth in population the land becomes more valuable for building sites than for cultivation, such acreage will cease to be cultivated, will build up in homes and while there will be a change in the employment of the water, the transition will be accomplished without change in the pipe line system or the quantity consumed. In figuring 1 in. to 5 acres the valley was assumed to be one great field under cultivation, no allowance being made for streets, walks, or wash areas which always will be required for flood drainage. It will therefore be seen that liberal and generous allotment above actual requirements has been made in the interest of safety.

All the mains are designed to deliver a head of 48 in. and, at 2.75 ft. per second in the smallest lateral; that is, 8 in., 30 hours every 30 days is the assumed requirement of a 10-acre tract.

The system is designed so that every 40-acre tract is touched by at least an 8-in. lateral. This is procured by running the laterals out from the trunk lines at half-mile intervals. Where sub-division has reduced the 40 acres into smaller units 6-in. laterals will be installed at a cost of 40 ct. per lineal foot, this being a direct charge to the property fronting the improvement and not being included as a part of the system installed under the bond issue.

The pressures, depending upon the locality, will range from a head of 15 to 300 ft.

The thicknesses of steel employed are for 8-in., 9-64-in.; 10-in., 7-64-in.; with 3-16-in. and ¼-in and increasing thickness on the larger mains, the basis being a safe working stress of 15,000 lb. per square inch of net section.

For gate valves, on 8 and 12-in. laterals, full size either wedge or double disk of the same diameter as the main will be used, with hub ends and concrete joints. These gates will be placed at one-half mile intervals. Gates on 14 to 20-in. mains will be spaced one mile apart and of a diameter of the standard size equal to or next larger than one-half the diameter of the pipe. On larger mains the rule of size will be the same, with spacing two miles apart. On ordinary pressures, gates to operate under 175 lb. tested to 300 lb. will be required.

All the mains are of single-plate construction with the riveting as described in the former article on the City Trunk line.

In the contract just awarded, the specifications called for delivery of the pipe fabricated into 24-ft. sections at the side of the trench, with all rivets necessary for field joints, payment to be made upon the basis of measurement of the pipe laid in the trench. For all pipe of 20-in. or smaller diameter, the field joints are to be driven.

The estimate of cost was figured on the basis of 5 ct. per pound for the pipe in the ground ready for service, 10 per cent for tools, engineering and supervision, and 2½ per cent for gates and fittings. The steel contract just let to local bidders figures on a pound basis, 3.506 ct. per pound trench side, and at this figure it is expected that the system can be installed within the estimate.

The pipe will be laid on the south and west sides of thoroughfares, the top of the pipe to be 30 in. from the top of the ground. Excavation for the trunk line conduits will be with Marion Model "40" steam shovels equipped with extra long boom, as shown in Fig. 3. The aqueduct has four of these which were employed in aqueduct construction. On laterals and small lines two Austin trenching machines have been purchased; the department has one Buckeye, shown in Fig. 4, and others will be purchased as the need arises. Camps operated by the city will be established at as many points as are required to keep pace with steel deliveries. Unless these under future contracts are unfavorable, from 18 months to 2 years will be required to consummate the work.

As an example of the large demand for water, last season by temporary ditches 6,000 acres were placed under irrigation and in the coming year 25,000 acres have been contracted and ploughing is now in progress, the agricultural associations which have been formed, in addition to such pipe lines as the city can lay in the next four months, assessing their members for the construction of 7 miles of flumes and 12 miles of ditches.

It was at first estimated that 20 years would elapse before the capacity of the system would be called upon. With such rapidity, however, have the large ranches been subdivided and sold in from 5 to 40-acre tracts and so quickly is the district being populated that within 6 to 8 years after the works are installed, it is expected that their full capacity will be utilized.

Entirely aside from the sales of water, the aspect of this commercial side of the aqueduct product will become apparent when one considers the gains to accrue to the city through avenues only indirectly remunerative to the municipality through sales of water. The intensive cultivation of such an area requires a small army of laborers, many of them highly skilled in horticulture, and produces large and valuable harvests the returns from which find their way into Los Angeles marts of trade.

The cost of the whole work is estimated at $4,472,674, which for the 87,211 acres would figure $50.90 an acre. However, as the city will require certain of the reservoirs and pipe lines as a part of the aqueduct storage and domestic system it has agreed to assume $1,466,674 of the burden. The voters of the district therefore assume a bonded indebtedness of $2,986,000, payable in 30 equal installments, the last installment falling due 40 years from the date of bond issue, which on an acreage basis figures approximately $34 per acre. Payment, however, is made not on an acreage, but upon an assessed valuation basis, and as the first payment of bond principal does not fall due until 10 years after the issuance of the bonds, the passage of the decade gives opportunity for the building of the works and the planting and bringing into bearing of trees so that the payments are borne out of the wealth which the building of the water works has itself created.

While no water right is sold, the fact that the whole area is within and a part of the city of Los Angeles makes it impossible to withdraw the water from the land so long as the consumer complies with the rules and regulations of the Water Department as they are in effect throughout the city.

The irrigation rate now in effect is 1 ct. per inch per hour. This amounts to 1.39 ct. per 100 cu. ft. as opposed to the domestic rate of 7 ct. per 100 cu. ft. Under the 1 ct. rate the equivalent of a rainfall covering an acre to the depth of 1 in. would cost the owner 50 ct. Under normal use, the owner of an orange or lemon grove at this rate would pay between $11 and $12 per acre per year for the water his grove would require.

The works have been designed and the construction will be carried on under the direction of William Mulholland, Chief Engineer of the Los Angeles City Water Works Bureau.

COST OF SURFACE OILING OF EARTH ROADS*

By B. H. Piepmeier, Maintenance Engineer, Illinois State Highway Department, Springfield, Ill.

The cost of preparing a public road for an oil treatment may vary from $100 to $2,000 per mile. However, the grading and preparation of an earth road should not be charged against the cost of oiling. The oiling or dragging of an earth road is a maintenance proposition and should be estimated separately from the building or preparing of the road. The road should be kept well shaped regardless of whether it is to be oiled or not. However, some cleaning is almost always necessary prior to the first application of oil, and this cost will vary from $25 to $50 per mile of road.

Road oil can can be purchased from 3 to 7 cts. per gallon, depending upon the quality. It may be applied on the surface of the road at the rate of ¼ to ½ gal. per square yard. So the cost of oil alone may vary from $75 to $275 per mile of road 15 ft. wide, depending upon the quality and quantity of oil applied.

The cost of applying the oil will vary depending upon the length of haul and the kind of equipment used. This cost may be estimated at from $50 to $150 per mile of road 15 ft. wide.

The above figures show the cost of oiling to vary from $150 to $475 per mile of road. With average conditions and with a medium priced oil, the average cost of oiling alone per application may be from $200 to $250 per mile of road 15 ft. wide.

It is understood that the above figures are only an approximate estimate. A complete record of the cost of oiling, together with the quality and quantity of oil used each year over a period of years is not available. The above figures, however, are based on the best information available in this and other similar states.

It is predicted by some enthusiastic users that a road will not require oiling after it has been oiled for two or three years and the surface has become thoroughly saturated with the oil. The writer has visited some twenty different towns that have oiled their streets for a period of more than five years and the present condition of such streets indicates that the oiling will have to be repeated each year indefinitely to secure the desired results. The quality or quantity of oil used in the twenty towns referred to is not known. It may be that if a high grade of asphaltic oil is used that some annual applications may be omitted after a few years of treatment. With the best oil, however, it is hardly expected that more than one year could elapse without some attention.

Some experiments have been made along the line of thoroughly saturating the top 6 ins. of earth and then compacting it with a petrolithic roller. The saturating of the earth with the first application of 2½ to 3 gals. of oil was intended to resemble somewhat the continual oiling of the surface over a period of four or five years. The experiments referred to were made in 1908 and 1909 on three different sections of road of one-half to three-fourths of a mile in length. Two of the sections were considered failures and were within three years covered with a more desirable wearing surface. The third section still remains; however, it shows very few signs of having such a treatment. This section seems to rut in the winter and spring almost as badly as the other portion of the road; in midsummer the surface of the road pulverizes and forms a dust that flies almost the same as dust from other portions of the road.

In view of all the information that is available on oiled earth roads, indications are that the treatments must be made each year or at least every other year to get the desired results. On this basis, $150 to $200 per year for five to ten years may be a basis for estimating the cost of surface oiling.

SOME HINTS ON DRILLING AND CONSTRUCTING DRIVEN WELLS.*

By John D. Kilpatrick, Consulting Engineer, New York City.

Methods of Drilling and Construction.—Driven wells may be roughly divided into two classes: (1) those where the water supply is obtained from the rock, and (2) those where the water bearing strata lie above the rock. A third class might be added, a combination of these two.

1. Where the rock lies at a short distance below the surface of the ground and the quality of the water above the rock is unsatisfactory, the pipe should be driven so as to seat firmly into the rock, shutting off the surface water. The most satisfactory method of doing this work in the case of the 8-in. finished hole in the rock, is to drive a 10-in. pipe down to the rock and drill a 10-in. hole in the rock far enough to be surely into the solid rock and below the shattered and seamy top surface. An 8-in. pipe should then be lowered to seat into the bottom of the 10-in. hole in the rock and cement grout poured in sufficiently to fill up the annular space around the 8-in. pipe in the 10-in. hole in the rock. After this is set and the 8-in. hole drilled on in the rock, the 10-in. pipe may be withdrawn for use in another well.

During the drilling of the well, tests should be made by means of sand bucket or working barrel to determine the yield at different depths. A good indication of passing through water bearing crevices is the rise or fall of the standing water in the well. If continued drilling shows the same character of rock and the standing water level remains the same, it is a good indication that there is no great change in the possible yield of the well. Another indication of very little water in a rock well is shown by a great rise in the water level in the well when the drilling tools are lowered. When the well has reached the required depth, a test should be made, either with the working barrel, or the air-lift. If there are a number of wells to be put in, and the air-lift system is to be adopted for the permanent pumping plant, and the test is made with a working barrel, it is advisable to place the working barrel at a point below the surface so as to leave sufficient depth for the submergence of the air-lift. For instance, if the wells are 200 ft. in depth, the writer would not recommend that the working barrel be placed more than 100 ft. below the surface of the ground and the yield determined at this point.

---

*Extract from Surface Oiling of Earth Roads, Bulletin No. 11, Illinois State Highway Department.

*From a paper and discussion before American Water Works Association published in Journal of Association for December, 1915.

2. The construction of wells in sand or gravel. In driving wells through sand or gravel, it is essential that the drive pipe be of strictly wrought iron and equipped with patent recessed couplings, and care must be taken so that the ends of the pipe butt in the couplings and that the pipe be shod on the lower or cutting edge with a steel drive shoe. The reason for the pipe butting in the couplings is to carry the effect of the blow of the tools directly through the pipe to the drive shoe instead of having the impact come upon the threads in the couplings.

The proper strainer and the placing of it is the next point to be considered. If the strainer is to be placed at the bottom of the well, this may be done either by driving the pipe through the water bearing strata, introducing the strainer, and jacking back the drive pipe so as to uncover it; or the drive pipe may only go to the top of the water bearing sand and the strainer pumped or driven into proper position. In the first case the strainer may be plugged before being lowered, but chances would be taken in the ability of the well driller to jack back the drive pipe. In the latter case, difficulty is sometimes found in placing the plug securely. In either method of construction, it is essential that means be taken to prevent sand from running up alongside the strainer between the top of the strainer and the well casing. This sand is kept out either by putting in a lead packer or by continuing an extra line of pipe from the strainer up to the surface of the ground. Where the lead packer is used, the strainer is lowered into the hole, and in order to withdraw it any time, considerable difficulty is usually found in getting hold of it and getting it out of the well without destroying the strainer. As a general rule, it is better to lower the strainer into place by means of piping extending all the way to the surface of the ground and then, if it is necessary at any future time to withdraw the strainer, it is a comparatively simple matter to do so. In case the water is found in three or four strata with some distance between them, it is necessary to drive the pipe to the extreme depth and then lower the strainers into place with the proper connecting pipes between them, and then jack out the well casing at least as far as the top of the uppermost strainer.

The operation of jacking back pipe is one involving risk on account of the pipe parting under the strain. The only precautions that can be taken are to sand pump freely and frequently when the pipe is being driven, have the strainers on the ground and lose no time in placing the strainers before jacking back the pipe, so that the sand and gravel will have as little time as possible to pack around the drive pipe couplings. Cutting the drive pipe may be resorted to in case it is unnecessary to withdraw the lower part of the drive pipe, which may have been driven to give the necessary amount of submergence in the case of an air-lift well. The necessity of insisting upon the pipe being butted in the coupling is observed more particularly when jacking operations are required, because if the pipe is not butted there is even greater danger of stripping the threads. In case a pipe parts when being jacked back, it may result in a lost well.

3. Under the third heading, where water may be obtained from the formations above the rock and from crevices in the rock, the construction of the well differs in no way from those referred to in the first two actions.

Shooting a Rock Water Well.—Shooting a well is resorted to in the oil regions to break up the oil-bearing sand, when this has been encountered. In shooting a well for water supply, a greater flow can sometimes be obtained if you are absolutely sure where the water bearing fissure in the rock has been encountered. The trouble with most well builders is that they cannot determine this exact point, and it may be that the shot is set at the wrong place, and may result in the closing up of the water bearing fissure instead of enlarging it. As a general rule the speaker does not believe that blasting a well is a sure way of increasing the water supply from that well, but at the same time there are a number of cases in which it has proven very successful.

Drilling a Straight Bore.—Whether a well hole is straight or not makes little or no difference when the well is to be pumped with the air lift system, but it makes a very great deal of difference if deep well pumps having long pump rods are employed. In driving a pipe it must be remembered that the direction of the hole is entirely dependent upon the threading of the casing. The well driller sets his first length of pipe as near vertical as he can, drives this to its depth, screws on another length, drills that, and sand pumps and drives till he is ready for the other length, etc. The straightness of the hole depends upon the care with which the pipe company has threaded the pipe. The reason that so many well drillers get a crooked hole in the rock is that they drill with a slack cable. The well driller will usually get a straight hole if he drills on the spring of the cable, that is, with the tools hanging free in the hole, the distance off the bottom depending entirely upon the length of drill cable. In drilling with a taut cable the tools hit with a sharp blow, which is caused by the fact that the up stroke of the walking beam corresponds with the stretch of the cable. In drilling with a slack cable the tools do not hang free and clear in the hole, and the length of the stroke is cut down considerably. It is a very difficult job to drill a straight hole even with the best of care, if the rock is in layers of very hard and very soft material lying almost vertically. In this case the tools will be sure to work over into the soft material and make a crooked hole, in spite of all precautions. Sometimes a guide can be put on the stem, but in an experience once in Mexico every method known at that time failed, and we were forced to drill with a rotary drill.

PROGRESS REPORT OF SPECIAL COMMITTEE OF AMERICAN SOCIETY OF CIVIL ENGINEERS ON STEEL COLUMNS AND STRUTS.*

The Special Committee on Steel Columns and Struts, appointed by the American Society of Civil Engineers, has made a progress report in which the results of a series of tests on various types of columns are summarized. A previous report of the committee, made about a year ago, showed that about 70 columns had then been tested. During the past year the Bureau of Standards has tested 110 additional columns, making a total of 180 which the committee has available for study and dis-

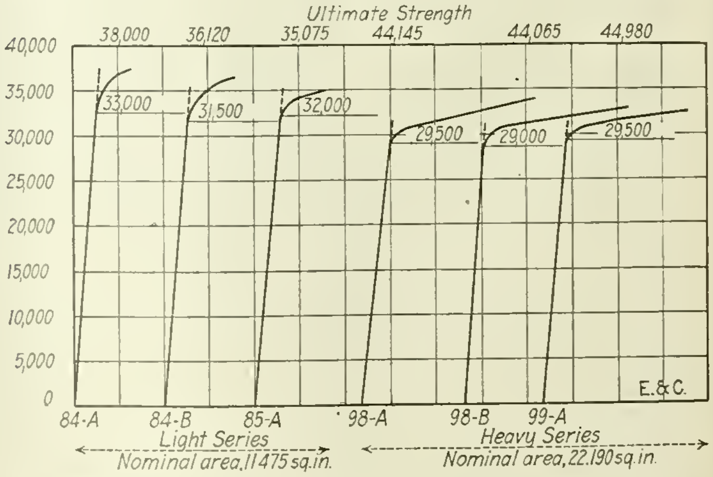


Fig. 1—Stress-Strain Curves for Column Tests 84-A, 84-B, 85-A, 98-A, 98-B and 99-A.

---

*Abstract from Proceedings, American Society of Civil Engineers, Vol. XLI, p. 2753.

TABLE 1. TYPES 1 & 1A – 1 & 1A SPECIAL

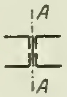
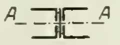
Type	Test nº	Section	Actual Area	Radius of Gyration	Length	$\frac{l}{r}$	Unit ultimate Strength.	Average ultimate Strength.	Deflection in inches at the Middle of Columns at the Reading just before Failure.	
1.	8	Light Sections	11.13	2.24	9'-4"	50	32400		0.035 S	0.000
	38		11.17	"	"	"	32800	32700	0.07 S	0.1000 Up.
	77		11.13	"	"	"	33000		0.050 N.	0.0313 Up
	18		11.49	"	15'-10$\frac{7}{16}$"	85	32100		0.12 S	0.05 Up
	84		11.49	"	"	"	31400	31200	0.0252 S.	0.1281 Down.
	85	4L^s 5"x3"x$\frac{5}{16}$"=9.60□"	11.35	"	"	"	30000		0.0626 N	0.1368 Up.
		1Pl. 6"x$\frac{5}{16}$"=1875								
	30	Total=11.475□"	11.20	"	22'-4$\frac{13}{16}$"	120	28600		0.000	0.060 Down.
	56		11.14	"			27600	28300	0.1175 S.	0.1091 Up.
	69		11.30	"			28700		0.0135 N.	0.1785 Down
1A	93	Heavy Sections	22.25	2.36	9'-10"	50	29000		0.0080 S.	0.0574 Down
	96		22.13	"	"	"	28900	29200	0.0731 N.	0.0457 Up.
	97		22.28	"	"	"	29700		0.0653 N.	0.0002 Up.
										
	91		22.134	"	16'-8$\frac{5}{8}$"	85	28000		0.0475 S.	0.0883 Up
	94		21.92	"	"	"	28200	28100	0.4053 N	0.2636 Up.
	95	4L^s 5"x3"x$\frac{5}{8}$"=18.44□"	22.05	"	"	"	28000		0.0764 N.	0.0825 Down.
		1Pl 6"x$\frac{5}{8}$"=3.75								
	92	Total=22.19□"	22.15	"	23'-7$\frac{3}{16}$"	120	25000		0.1430 S.	0.2923 Down
	98		22.10	"	"	"	25500	25400	0.3863 N	0.0762 Up.
	99		22.10	"	"	"	25800		0.1326 N	0.0606 Down
1 Spec.	85A	Light Sections	11.35	2.24	3'-8$\frac{3}{4}$"	20	35100		0.0089 N	0.0600 Down
	84A		11.49	"	"	"	38000	36400	0.0230 S.	0.0313 Up.
	84B		11.49	"	"	"	36100		0.0141 S.	0.0120 Down.
		as above								
1A Spec.	99A	Heavy Sections	22.10	2.36	3'-11$\frac{3}{16}$"	20	45000		0.0209 S	0.0157 Down.
	98A		"	"	"	"	44100	44400	0.0177 N	0.0104 Down
	98B		"	"	"	"	44100		0.0031 N.	0.0229 Up
		as above								

TABLE 2. TYPES 2 & 2A – 3 & 3A

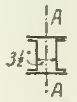
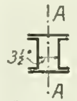
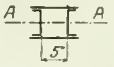
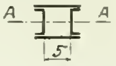
Type	Test no.	Section	Actual Area	Radius of Gyration	Length.	$\frac{l}{r}$	Unit Ultimate Strength	Average Ultimate Strength.	Deflection in inches at the Middle of Columns at the Reading just before Failure	
2	11	Light Sections.	10.06	2.31	9'-7$\frac{1}{2}$"	50	33100		0.08 S	0.00
	41		10.15	"	"	"	34000	33900	0.0024 N.	0.0374 Up
	43		10.06	"	"	"	34500		0.0460 S	0.0441 Up
	21		9.92	"	16'-4$\frac{3}{8}$"	85	33700		0.12 S.	0.04 Up.
	59		9.87	"	"	"	32300	32600	0.1195 N.	0.0195 Up
	65	2-6"[^{s}x10.5-lb.=6.18□"	10.05	"	"	"	31700		0.0627 N	0.0927 Down
		2Pl^s 8"x$\frac{1}{4}$"=4.00								
	32	Total=10.18□"	10.01	"	23'-1$\frac{3}{16}$"	120	28300		0.27 S	0.12 Up
	54		10.09	"	"	"	28700	29300	0.2750 S.	0.0583 Up
	70		10.07	"	"	"	30900		0.1725 N.	0.0144 Up
2A	101	Heavy Sections.	17.07	2.33	9'-8$\frac{1}{2}$"	50	32200		0.0318 N	0.0360 Up.
	124		17.07	"	"	"	32500	32300	0.0052 N.	0.0044 Up.
	165		16.96	"	"	"	32300		0.1905 S.	0.0131 Up.
	145		17.07	"	16'-6$\frac{1}{16}$"	85	30700		0.0416 N	0.0820 Down
	146		17.02	"	"	"	30000	30600	0.0606 S.	0.0731 Up
	151	2-6"[^{s}x15.5-lb.=9.12□"	17.11	"	"	"	31000		0.0312 S.	0.0078 Down
		2Pl^s 8"x$\frac{1}{2}$"=8.00								
	135	Total =17.12□"	17.04	"	23'-3$\frac{5}{8}$"	120	28500		0.0668 S.	0.0298 Up.
	136		17.02	"	"	"	28800	28100	0.1315 S.	0.1942 Up
	137		17.08	"	"	"	27000		0.1503 N.	0.0339 Down
3	1	Light Sections.	8.71	2.34	9'-9"	50	33800		0.01 N	0.06 Up.
	2		8.80	"	"	"	34300	34100	0.01 S.	0.04 Up.
	42		8.71	"	"	"	34300		0.0418 N.	0.0306 Up.
	14		8.71	"	16'-6$\frac{7}{8}$"	85	32500		0.10 N.	0.06 Down.
	87		8.69	"	"	"	31900	32400	0.0764 S.	0.1994 Down
	88	2-5"[^{s}x6.5-lb.=3.90□"	8.60	"	"	"	32900		0.0470 S.	0.1774 Up.
		2Pl^s 9$\frac{1}{2}$"x$\frac{1}{4}$"=4.75								
	24	Total=8.65□"	8.79	"	23'-4$\frac{13}{16}$"	120	31600		0.13 N.	0.01 Up
	35		8.70	"	"	"	30200	30600	0.17 S.	0.08 Down.
	47		8.74	"	"	"	30000		0.2056 N	0.1404 Down
3A	105	Heavy Sections.	16.44	2.39	9'-11$\frac{1}{2}$"	50	29800		0.0084 N.	0.1044 Down.
	168		16.45	"	"	"	29300	29500	0.0077 N	0.0170 Up.
	171		16.39	"	"	"	29500		0.0126 N.	0.0228 Up.
	147		16.41	"	16'-11$\frac{1}{8}$"	85	28000		0.0574 S.	0.0721 Down.
	148		16.39	"	"	"	28000	28000	0.0313 N.	0.0470 Down.
	150	2-5"[^{s}x11.5-lb.=6.76□"	16.37	"	"	"	28000		0.1159 N	0.0835 Up.
		2Pl^s 9$\frac{1}{2}$"x$\frac{1}{2}$"=9.50								
	138	Total=16.26□"	16.50	"	23'-10$\frac{13}{16}$"	120	28000		0.1848 S.	0.0449 Down.
	139		16.45	"	"	"	26100	26900	0.0919 N.	0.3284 Down.
	143		16.42	"	"	"	26600		0.1201 N.	0.3920 Up.

TABLE 3. TYPES 4 & 4A – 5 & 5A.

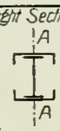
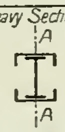
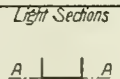
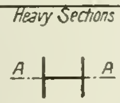
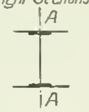
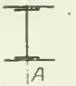
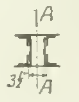
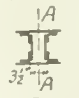
Type	Test no.	Section.	Actual Area	Radius of Gyration	Length	$\frac{l}{r}$	Unit Ultimate Strength	Average Ultimate Strength	Deflection in inches at the Middle of Columns at the Reading just before Failure	
4	6	Light Sections.	11.69	2.38	9'-11"	50	35700		0.11 N.	0.015 Down
	36		"	"	"	"	36500	36900	0.02 S.	0.04 Up
	75		"	"	"	"	38600		0.0480 S.	0.0021 Up.
	13		11.66	"	16'-10$\frac{5}{16}$"	85	34000		0.04	0.06 Up.
	79		11.73	"	"	"	33900	34000	0.1409 N.	0.0345 Up.
	80	2-8"[^{s}x11.25-lb.=6.70□"	11.64	"	"	"	34000		0.0626 S.	0.1304 Down
		1-8"Ix18.00-lb.=5.33								
	26	Total=12.03□"	11.69	"	23'-9$\frac{5}{8}$"	120	32000		0.15 S.	0.10
	45		11.61	"	"	"	30700	31900	0.409 N.	0.0216
	49		11.68	"	"	"	33100		0.0712 N	0.0094 Up
4A	102	Heavy Sections	16.98	2.32	9'-8"	50	30300		0.0158 N	0.0169 Down.
	166		16.84	"	"	"	29000	29100	0.0504 S.	0.0150 Down.
	169		16.81	"	"	"	28000		0.0311 S.	0.0019 Up.
	152		16.86	"	16'-5$\frac{3}{16}$"	85	26000		0.1044 N	0.0093 Up
	153		16.89	"	"	"	26400	26600	0.2453 S	0.0261 Down
	154	2-8"[^{s}x18.75-lb.=11.02□"	17.00	"	"	"	27500		0.0835 N	0.0078 Down
		1-8"Ix20.50-lb.=6.03								
	132	Total=17.05□"	16.98	"	23'-2$\frac{7}{16}$"	120	23500		0.4176 S.	0.0052 Down
	133		17.07	"	"	"	23900	23900	0.2349 S.	0.0068 Up.
	134		16.96	"	"	"	24200		0.5283 N	0.0616 Down
5	107	Light Sections	9.62	1.98	8'-3"	50	38000		0.0280 N.	0.0115 Down
	122		9.65	"	"	"	38000	38000	0.0836 N.	0.0287 Down
	123		9.65	"	"	"	38000		0.0052 S.	0.0209 Down
	114		8.61	"	14-0$\frac{5}{16}$"	85	36000		0.1510 S.	0.0078 Down
	116		9.66	"	"	"	34000	34300	0.1148 S	0.0085 Up.
	119	Beth. 8"H Col x32-lb.	9.59	"	"	"	33000		0.1201 S.	0.0376 Up.
		=9.17□"								
	110		8.64	"	19'-9$\frac{5}{8}$"	120	33900		0.1148 N.	0.0084 Up
	111		8.68	"	"	"	31000	32000	0.2140 N.	0.0136 Down
	108		8.61	"	"	"	31000		0.1806 S.	0.0110 Up.
5A	106	Heavy Sections	17.86	2.09	8'-8$\frac{1}{2}$"	50	34000		0.1201 N.	0.0084 Up.
	120		17.82	"	"	"	36100	35400	0.0606 N.	0.0016 Up.
	121		17.86	"	"	"	36000		0.0284 N.	0.0033 Up.
	115		18.05	"	14'-9$\frac{5}{8}$"	85	33900		0.0521 N.	0.0151 Down
	117		17.73	"	"	"	32000	32300	0.0929 N.	0.0054 Down.
	118	Beth. 8"H Col x62-lb	17.77	"	"	"	31000		0.0470 S.	0.0277 Up
		=18.27□"								
	109		17.76	"	20'-10$\frac{13}{16}$"	120	30000		0.1498 N.	0.0037 Up
	112		17.97	"	"	"	30000	30000	0.2401 S.	0.0219 Down.
	113		17.73	"	"	"	30000		0.1610 N.	0.0221 Down.

TABLE 4. TYPES 6 & 6A – 10 & 10A.

Type	Test no	Section.	Actual Area	Radius of Gyration	Length	$\frac{l}{r}$	Unit Ultimate Strength.	Average Ultimate Strength.	Deflection in inches at the Middle of Columns at the Reading just before Failure.	
6	10	Light Sections.	13.72	2.31	9'-7$\frac{1}{2}$"	50	31200		0.11 N.	0.01 Up
	40		13.78	"	"	"	31500	31600	0.0837 S.	0.0065 Up.
	44		13.72	"	"	"	32200		0.0250 N	0.0020 Up
	22		13.65	"	16'-4$\frac{3}{8}$"	85	27800		0.30 N	0.02 Up
	63		13.68	"	"	"	29500	29100	0.3040 N.	0.0097 Down.
	64	1-I 10"x25-lb.=7.37□"	13.60	"	"	"	30100		0.1306 S.	0.0166 Down
		2Pl^s 11"x$\frac{5}{16}$"=6.88								
	31	Total=14.25□"	13.73	"	23'-1$\frac{3}{16}$"	120	26700		0.50 S.	0.04 Up
	52		13.75	"	"	"	27700	27200	0.1980 S.	0.0190 Down
	71		13.65	"	"	"	27300		0.1369 S	0.0013 Up
6A	103	Heavy Sections.	23.98	2.47	10'-3$\frac{1}{2}$"	50	31200		0.0175 S.	0.0019 Down.
	125		23.75	"	"	"	32800	32100	0.0078 S.	0.0076 Up.
	128		23.72	"	"	"	32400		0.0496 N.	0.0042 Up
	155		23.69	"	17'-5$\frac{15}{16}$"	85	27200		0.3028 N.	0.0061 Up
	158		23.73	"	"	"	26800	26800	0.3341 N.	0.0312 Down.
	159	1-I 10"x35-lb.=10.29□"	23.72	"	"	"	26400		0.3341 S	0.0522 Down
		2Pl^s 11"x$\frac{5}{8}$"=13.75								
	129	Total = 24.04□"	23.64	"	24'-8$\frac{3}{8}$"	120	24900		0.1827 S	0.0097 Up.
	130		23.83	"	"	"	24000	24800	0.4100 S.	0.0157 Down
	131		23.76	"	"	"	25500		0.3654 N	0.0099 Up
10	3	Light Sections	10.77	2.33	9'-8$\frac{1}{2}$"	50	36100		0.06 S.	0.055 Up
	4		10.80	"	"	"	35700	35800	0.05 N	0.0251 Up
	53		10.86	"	"	"	35600		0.0118 N.	0.0217 Up
	19		10.78	"	16'-6$\frac{1}{16}$"	85	32500		0.29 S	0.200 Up
	83		10.76	"	"	"	31900	32100	0.0239 N	0.1117 Down
	86	2Pl^s 9"x$\frac{1}{4}$"=4.500□"	10.76	"	"	"	31900		0.2611 N	0.0786 Down
		4L^s 2"x2"x$\frac{1}{4}$"=3.760								
	23	2Pl^s 5$\frac{1}{4}$"x$\frac{1}{4}$"=2.625	10.75	"	23'-3$\frac{5}{8}$"	120	28400		0.30 N.	0.05 Down
	33	Total=10.885□"	10.76	"	"	"	28300	28400	0.23 S.	0.03 Up
	34		10.75	"	"	"	28400		0.20 S	0.00
10A	104	Heavy Sections.	18.60	2.34	9'-9"	50	31400		0.0360 S	0.1556 Down.
	167		18.52	"	"	"	32000	31800	0.0099 N	0.0851 Down.
	170		18.46	"	"	"	32100		0.0783 N	0.0188 Down.
	144		18.67	"	16'-6$\frac{7}{8}$"	85	28000		0.0292 S	0.1044 Down.
	149		18.65	"	"	"	28000	28300	0.1545 S	0.0992 Down.
	157	2Pl^s 9"x$\frac{7}{16}$"=7.88□"	18.69	"	"	"	29000		0.0731 N	0.0010 Down.
		4L^s 2"x2"x$\frac{7}{16}$"=6.24								
	140	2Pl^s 5$\frac{1}{4}$"x$\frac{7}{16}$"=4.59	18.64	"	23'-4$\frac{13}{16}$"	120	27000		0.0392 N.	0.1080 Up.
	141	Total= 18.71□"	18.80	"	"	"	25900	26300	0.2260 S.	0.1112 Up.
	142		18.65	"	"	"	26000		0.2297 S	0.1113 Up.

Tables I-IV—Abstract of Record of Column Tests Reported by Special Committee of American Society of Civil Engineers—Also See Table V.

cussion. These include 16 light and heavy sections of different types of built-up columns; 18 Bethlehem H-columns, light and heavy sections; and 18 Carnegie mine section, H-columns, light sections.

A study of the 70 columns previously reported showed that the committee would be assisted in interpreting the results if comparisons could be made with columns of different slenderness ratios than the 50, 85 and 120 l/r used. It was, however, felt that the difference in slenderness ratio of 35 l/r was small enough to give ample information of the character of columns anywhere within this range. It was therefore decided to extend the series, maintaining the same progressive ratio of 35 l/r, and adopting a new slenderness ratio of 155 l/r.

After the first series of tests on light columns was completed it was suggested that it would be possible to take some of the long columns and cut pieces from them which would be available for tests of short struts. Three light and three heavy struts were cut from the plate-and-angle columns, Type 1, so as to give a slenderness ratio of 20 l/r. These were tested, and the results are shown in Table I as tests 84-A, 84-B, 85-A, and 98-A, 98-B, 99-A. It will be noted that the system of numbering indicates the numbers of the original test columns from which these pieces were cut.

Originally the committee planned ten different shapes of columns, covering commercial forms, with the idea of varying these forms to discover the effect of variability of shape on the strength of the column. Nine of these types have been made and tested, and the tenth one, which was of circular form, has been omitted, as it has not been practicable to obtain a circular column with the same high quality of material which has been provided in the rest of the series.

Types 1, 2, 3 and 10 (see Tables I, II and IV) are the commercial riveted shapes most commonly used at the present time. Type 5 (see Table III) has met with much favor in building work. It had been suggested to the committee that failure may frequently be due to the fact that thin outstanding legs cripple before the main section of the column is seriously effected by the load, and therefore Types 4, 7 and 8 (see Tables III and V) were selected to determine the effect of a square corner or a bulb on the edge of the outstanding legs.

Results of Tests to Date and Discussion.

The results of tests made to date are abstracted in Tables I to V, inclusive. By referring to these tables it will be noted that the arrangement of data is such that the light and heavy sections of each type are placed together, to facilitate comparisons.

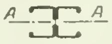
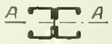
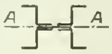
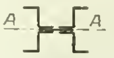
A study of the results of tests of Types 4, 7 and 8, which were selected to determine the effect of sections with square corners or bulbs, failed to disclose any considerable difference due to these factors; when the effect of light and heavy sections was considered, however, there is a marked difference in favor of the thin material. The variation in this rule appears in the columns of Type 6, with slenderness ratio of 50 l/r (see Table IV), this column having an I-shape with two thin plates riveted to the flanges of the I-beam. The committee realized that such an arrangement was not considered good standard practice, but it desired to determine the effect of thin outstanding edges.

The general falling off of the unit ultimate strength for heavy sections carries through all the other types of columns, and it will be noted that this is also true for the Bethlehem H-columns, which are solid rolled sections, as well as for the riveted sections.

Up to the present time the committee's studies have not progressed sufficiently to enable it to draw a conclusion as to the falling off of the strength of the heavy material. To assist those who desire to study this problem Table VI, which gives the results of chemical and physical specimen tensile tests for the columns of Types 1 and 1-A, is given.

A study of the stress-strain curves for tests 84-A, 84-B, 85-A, 98-A, 98-B and 99-A, which are shown in Fig. 1, serves to throw some additional light on the problem. These test columns were cut from longer columns having the same test numbers (as has been previously noted), to give short columns with a slenderness ratio of 20 l/r. It will be noted that, even though the heavy sections of these short columns had a unit ultimate strength considerably higher than that of the light sections, the stress-strain curve indicates that the yield point of the heavy sections is lower than that of the light sections. These columns were tested in accordance with the regular programme of loadings up to 5,000, 10,000. 15,000, 20,000, 25,000 and 30,000 lb. per square inch, dropping back in each case to the initial load of 1,000 lb. per square inch; and, as part of the original long columns, they had previously been subjected to the same programme of loading.

TABLE 5. TYPES 7 & 7A – 8 & 8A

Type	Test No	Section.	Actual Area	Radius of Gyration	Length.	$\frac{l}{r}$	Unit Ultimate Strength	Average Ultimate Strength	Deflection in inches at the Middle of Columns at the Reading just before Failure.	
7	5	Light Sections	13.33	2.48	10'-4"	50	34300		0.00	0.03 Down
	37		13.30	"	"	"	32700	33400	0.02 S.	0.04 Up
	76		13.33	"	"	"	33200		0.0034 N	0.1628 Down
	15		13.40	"	17'-6 13/16"	85	34000		0.10 S.	0.40 Up.
	89		13.43	"	"	"	30000	31600	0.1081 N.	0.2923 Up.
	90	4-5" Bulb L x 10.1-lb = 11.88 □"	13.29	"	"	"	30700		0.0914 N.	0.1670 Up.
		1 Pl. 6" x 5/16" = 1.88								
	28	Total = 13.76 □"	13.36	"	24'-9 5/8"	120	28300		0.05 S.	0.18 Up.
	48		13.34	"	"	"	26900	28100	0.0137 N.	0.3020 Down
	51		13.33	"	"	"	29000		0.0020 N.	0.0160 Up
7A*		Heavy Sections.								
										
		4-5" Bulb L's x 13.50-lb = 15.88 □"								
		1 Pl. 6" x 7/16" = 2.63								
		Total = 18.51 □"								
8	9	Light Sections.	10.98	2.46	10'-3"	50	35900		0.00	0.03 Down
	39		11.01	"	"	"	35100	35700	0.06 S.	0.06 Up
	78		11.03	"	"	"	36200		0.0072 S.	0.0086 Up.
	16		11.09	"	17'-5 1/8"	85	31400		0.03 S.	0.11 Up.
	81		11.05	"	"	"	32900	32800	0.0324 N	0.0653 Up.
	82	4-4" Z's x 1/4" = 9.64 □"	11.11	"	"	"	34000		0.0117 S.	0.1597 Up.
		1 Pl. 7" x 1/4" = 1.75								
	27	Total = 11.39 □"	11.06	"	24'-7 3/16"	120	29100		0.07 N.	0.06 Down.
	46		11.11	"	"	"	29400	29700	0.0417	0.0194 Up.
	50		11.16	"	"	"	30400		0.0088 N.	0.1281 Down
8A	100	Heavy Sections	25.78	2.51	10'-5 1/2"	50	33000		0.0235 N.	0.0431 Down
	126		25.86	"	"	"	33500	32900	0.0313 N.	0.0940 Down.
	127		25.83	"	"	"	32200		0.0261 N.	0.2400 Down.
	156		25.56	"	17'-9 3/8"	85	31300		0.0835 S.	0.2297 Up.
	160		25.57	"	"	"	25300	29400	0.0010 S.	0.3393 Up.
	161	4-4" Z's x 5/8" = 22.20 □"	25.43	"	"	"	31500		0.0459 N.	0.1462 Up.
		1 Pl. 7" x 5/8" = 4.38								
	162	Total = 26.58 □"	25.66	"	25'-1 3/16"	120	27500		0.1019 S.	0.3075 Up.
	163		25.70	"	"	"	27000	27300	0.0848 N	0.2025 Down
	164		25.68	"	"	"	27500		0.0032 N	0.760 Down.

* Tests have not been made

Table V—Abstract of Record of Column Tests Covering Types 7, 7A, 8 and 8A—Also See Tables I-IV.

The curves in Fig. 1 are all plotted for the seventh ap-

TABLE VI.—RESULTS OF CHEMICAL AND OF PHYSICAL SPECIMEN TENSILE TESTS OF TYPE 1 COLUMN MATERIAL.

Section.	Heat No.	Yield point.	Ultimate strength.	Carbon.	Manganese.	Phosphorus.	Sulphur
Columns, Type 1; Light Section.							
6×5/16 webs......	11,105	34,450	60,260	0.20	0.47	0.010	0.038
		32,950	59,730				
		35,480*	59,680				
		36,950*	60,860				
5×3×5/16 angles.	42,171	34,270	57,990	0.20	0.44	0.010	0.028
		34,070	57,740				
Average		34,695	59,380				

*Slow-speed test made with aid of magnifying glass by Bureau of Standards.

Section.	Heat No.	Yield point.	Ultimate strength.	Carbon.	Manganese.	Phosphorus.	Sulphur
Columns, Type 1-A; Heavy Section.							
6×⅝ webs........	38,054	36,940	58,400	0.20	0.40	0.020	0.032
		36,790	58,100				
5×3×⅝ angles.	13,354	38,280	61,430	0.20	0.40	0.010	0.031
		38,800	60,920				
	1,257	38,300	60,460	0.22	0.50	0.015	0.030
		39,100	58,970				
	10,032	38,280	57,800	0.20	0.46	0.019	0.031
		38,240	58,760				
Average	.....	38,090	59,355				

plication, or run-up, of the load. In the case of the light sections the yield points for the seventh run-up are well above 30,000 lb., and as the sixth run-up and the ultimate on the original column No. 85 alone reached this load it is probable that the yield points were not materially raised by previous run-ups. In the case of the heavy sections, however, the yield points, even after the seventh run-up, were below 30,000 lb., and these had been exceeded on the sixth run-up. There is little doubt, therefore, that the original yield point for these sections were less than that shown by the seventh run-up, it having been artificially raised by the sixth run-up. Until tests can be made on short columns, with a slenderness ratio of 20 l/r, which have not been previously stressed, the committee does not care to do any more than to draw attention to the yield points indicated by the stress-strain curves, with the thought that this information may indicate the way toward the correct solution.

At the time the material for the original columns was ordered the Bureau of Standards arranged to have the rolling mill furnish 5-ft. length pieces from each melt, for special physical and chemical tests. In order that the subject may have careful investigation the Bureau is now making a series of re-tests on the steel from each melt number. These tests are to be made on short specimen sections, in compression as well as in tension, and it is hoped they will throw additional light on the problem.

In the tests of Z-bar columns, Type 8, with a slenderness ratio of 50 l/r (see Table V), it was noted that the light sections gave results comparing favorably with other types, but that in failure there was a marked tendency for the outstanding legs of the Z-bars to twist to a marked extent. The heavy section Z-bar columns indicated the same falling off of unit ultimate which was shown by the other types, but the tendency to twist was not in evidence.

No attempt has been made to indicate a yield point for the columns with a slenderness ratio of 50 to 120 l/r. The stress-strain curves in Fig. 1 for the columns with a slenderness ratio of 20 l/r very clearly indicate a yield point, and the committee has given this question careful study to see if a yield point can be accurately determined for the longer columns. In making the tests the compressions were carried to unit loadings of 5,000, 10,000, 15,000, 20,000 and 25,000 lb. and were dropped back to the initial load of 1,000 lb. From a study of this series of tests it would seem that initial sets occur at very small loadings, and that these initial sets could be measured if instruments could be obtained of sufficient precision for the purpose. It would seem from the tests thus far studied that the yield point for the short columns is appreciably below the ultimate strength, but for the longer columns, in which bending action is shown, the yield point and the ultimate are probably very close together.

Thus far the committee has been engaged in the practical investigation of the details of the column tests, and it has not yet had an opportunity to co-ordinate these practical results with theoretical investigations.

Personnel.—The special committee having this work in charge consists of: Jas. H. Edwards, Chas. F. Loweth, Rudolph P. Miller, Ralph Modjeski, Frank P. Osborn, Geo. F. Swain, Emil Swensson, J. R. Worcester, Geo. H. Pegram, chairman, and Lewis D. Rights, secretary. The committee has been assisted in its work by the Bureau of Standards, S. W. Stratton, director; G. R. Olshausen, engineer-physicist.

Free Agricultural Engineering for Ohio Farmers.—Ohio farmers who wish to lay out special systems of land drainage, water supply or sewage disposal plants on their farms, can receive assistance from the Extension Department of Ohio State University at Columbus, for the asking. The department, on request, will send an engineer to run the requisite lines and levels and to offer suggestions as to the best method to pursue. No fee is to be charged for these services but the farmers in the community are to be invited to witness the demonstration of engineering skill.

COST OF OPERATING WHEEL TYPE EXCAVATORS IN DRAINAGE DITCHING.

By D. L. Yarnell, Drainage Engineer, U. S. Department of Agriculture.*

Two machines of the wheel type designed to cut a ditch 4 ft. deep, 4 ft. wide at the top, and 2 ft. wide at the bottom, were used on the excavation of some ditches in one of the Gulf States. Each machine was driven by a 28-hp. gasoline engine. The digging wheel was 15 ft. in diameter and the two apron tractors each 5 ft. by 12 ft. The weight of each excavator was about 30 tons. The first cost of the machine was $5,500 and freight to the point of use was $338.36, making the total cost of each machine $5,838.36. The soil was a hard, yellow, sandy clay overlain by a turfy muck, varying in depth up to 2½ ft. The turf was easily cut, but the hard clay caused excessive wearing on the bearings. A large part of the work was done when water was from 2 to 3 ft. deep on the land. The total length of the ditches dug was 165 miles, the average length of ditch being 2,475 ft. The average depth of digging was about 4 ft., with a 4-ft. top and 2-ft. bottom. The average distance dug per shift of 10 hours of actual running time was 2,250 ft.; the maximum distance dug in 10 hours was 6,600 ft. The average yardages per month for the two machines were 13,245 and 13,180 cu. yds., respectively. The average daily outputs on the basis of the actual running time were 1,000 and 1,126 cu. yd., respectively. A part of the time the first machine ran a double shift, which accounts for the higher monthly and less daily average. It required 13 months to complete the work, the actual time of operation being about half this. On account of the excessive wearing on the bearings, caused by the heavy sandy clay, it was necessary to make frequent stops for rebuilding the machines, which operation occupied an average of nearly two weeks. The total excavation was 317,162 cu. yd.

The daily operating expense per 10-hour shift for each machine was about as follows:

	Per day.
One operator, at $100 per month	$ 4.00
One assistant	2.00
50 gallons gasoline, at 16 cents	8.00
Repairs	6.00
Other charges	12.00
Total	$32.00

The itemized cost for operation for the entire work was as follows:

Labor	$ 5,172.11
Interest, discount, and exchange	202.05
Maintenance and repairs	2,860.68
General expense	273.10
Management expense	1,600.00
Provisions and cooking (cook's wages)	2,245.91
Freight and express	75.74
Towing	458.19
Gasoline	1,792.22
Other oil	281.49
Teams and livery	932.11
Telephone and telegraph	25.29
Motor boat operation	540.96
Interest and depreciation on machinery	5,185.00
Total	$21,644.25

Cost per cubic yard, $0.0682.

	Machine No. 1.	Machine No. 2.
Machine running	$ 917.97	$1,509.66
Machine repairing	1,431.37	771.96
Machine moving	105.20	88.51
Machine bogged	156.90	190.54
Total	$2,611.44	$2,560.67

The excessive cost of labor given for the machines when bogged was due to the frequent crossings of a wide, muck-filled bayou which ran the entire length of the district. This bayou was about 1,500 ft. wide; the muck ranged from 5 to 15 ft. deep and was very soft. No tree roots, submerged timber, or stumps were encountered. The work covered an area of about 7,000 acres, approximately square, which was traversed by parallel canals every half mile. The ditches cut by the excavators were at right angles to these canals and were spaced 330 ft. apart. It was thus necessary to turn the machine around and run it light 330 ft. for each half mile of ditch cut. The item "moving" is for taking the machine across the canals and for moving from one part of the district to another; it does not refer to the moving between adjacent ditches.

---

*Extract from Bulletin No. 300, Office of Public Roads and Road Engineering, on "Excavating Machinery Used in Land Drainage."

On a project in southern Louisiana a wheel excavator, cutting a ditch 4½ ft. deep with a top width of 4½ ft. and a bottom width of about 20 in., was used. The machine worked on comparatively solid ground. Power was supplied by a 28-hp. gasoline engine. The first cost was $4,000, and freight charges from factory to works were $350. After the machine had been operated for a short time it became apparent that the excavating wheel was far too light and a new wheel was substituted. The soil was a silt loam, firm and uniform but not tenacious. No special difficulties due to soil conditions were encountered in this work. The chief obstacles to rapid progress were at first the weakness of the light excavating wheel, and afterwards the extra-heavy excavating wheel which unbalanced the machine. The tractors were larger than necessary and often broke down when turning on the hard ground. At the time the following cost records terminated, the work had been carried on intermittently for about 18 months; about one-half this time was occupied in repairs. During this time the machines dug 117,000 ft. of ditch 4½ ft. deep, 45,500 ft. 3½ ft. deep, and 9,250 ft. twice over, the machine making two 4½-ft. cuts side by side. The average length of ditch cut per day was 800 ft., while the maximum was 1,950 ft. The daily cost of operation was as follows:

Labor	$ 5.50
Fuel	4.20
Incidentals	.50
Repairs	2.40
Total	$12.60

The average excavation per day was 410 cu. yd., based on the average of 800 ft. of ditch, 4½ ft. deep, 4½ ft. wide at the top, and 20 in. wide at the bottom. The machine excavated 82,330 cu. yd. in 18 months at the following itemized cost:

Gasoline based on 215 actual days' operation (estimated)	$ 903.00
Repairs, actual cost	860.00
Incidentals at 50 cents per day	120.25
Labor of foreman, 18 months, at $75 per month	1,350.00
Other labor, two men, $2.50 per day for 250 days	625.00
Interest and depreciation	2,675.25
Total	$6,533.50

Cost per cubic yard, $0.0793.

DESIGN AND CONSTRUCTION OF TANKS FOR TEMPORARY STORAGE OF STORM WATER AT TORONTO, ONTARIO.*

By W. G. Cameron, District Engineer, Sewer Section, Department of Works, Toronto, Ontario, Canada.

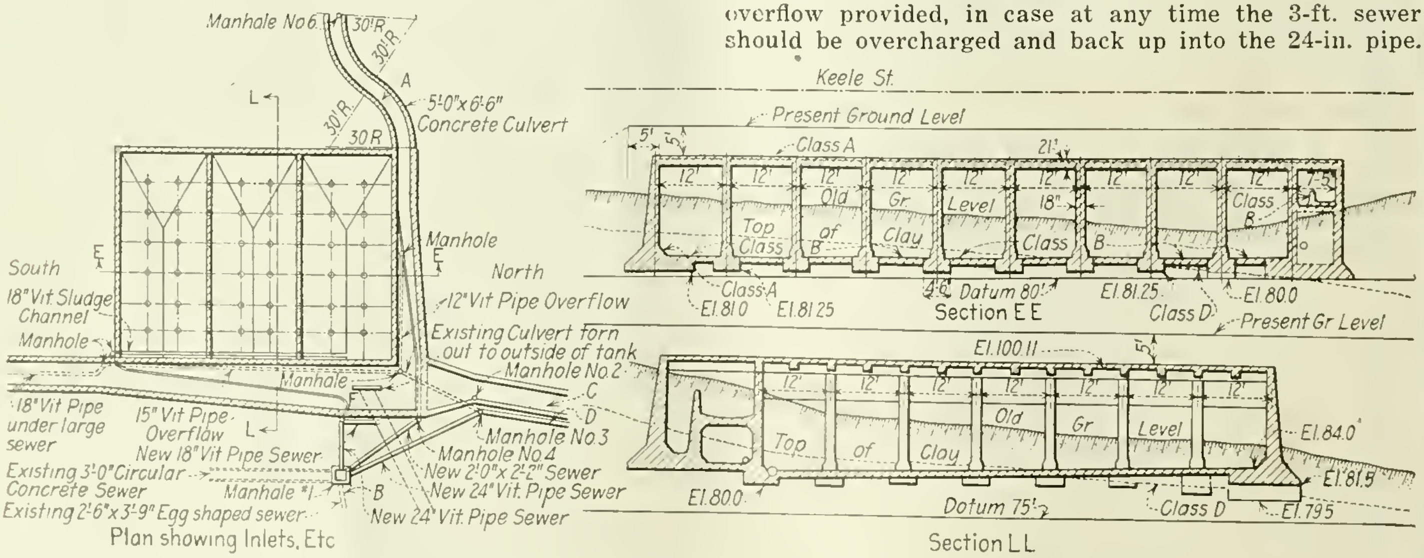
The West Toronto stand-by tanks are situated at the southwest corner of Keele and Bloor Sts., in High Park. The site, which is the lowest ground in this neighborhood, is the bed of a small creek which crosses Keele St. immediately south of Bloor. The creek is nearly dry except for storm and spring flood water. Keele St. is filled in across this creek and is about 15 ft. above the level of the present top of the tanks. A culvert is provided where the fill was made, and now discharges into the storm water outlet. The site was covered with small trees and scrub, and in places was wet and boggy.

Purpose of Tanks.—The object of the tanks is to provide a temporary storage for flood and storm water. If the volume of water is not too great for the capacity of the tanks, it is discharged gradually into the 18-in. sewer under the large storm water outlet, and carried eventually to the disposal works at Morley Ave. In this way, the 18-in. sewer is not overtaxed. If, on the other hand, the volume of water is not too great for the capacity of the tanks, the water is discharged over weirs into the large storm water outlet. But the tanks provide a temporary resting place where the detritus, etc., may settle, and, when the storm has subsided, may be drawn off in the 18-in. sewer, while only the very dilute water from the surface passes directly to the lake without being treated.

Inlets.—The inlet sewers were all built before the tanks were constructed, so the tanks formed the missing link in the system. There were three of these inlets, one from the west, marked A on the plan, one from the east (B) along Bloor St., and one from the north (C) along Keele St. Inlet C is a 7-ft. 6-in. by 8-ft. concrete culvert, into which flows a 9-ft. 3-in. circular sewer. The sewer from the west enters the tanks at the north end of the west side as a 6-ft. 9-in. by 5-ft. culvert. The drainage flows into a channel across the north end of the tanks, contained on the one side by the north wall of the tanks, and on the other by a weir. By means of this weir, the dry flow is guided into a smooth 2-ft. by 2-ft. 2-in. culvert, which discharges into an existing 3-ft. sewer down Keele St. The storm water passes over the weir into the tanks. If, at some future time, the 3-ft. sewer down Keele St. be overcharged, a 12-in. pipe sewer is provided, and, by opening a valve at the weir, the surplus can be drawn off through it into the 18-in. pipe under the storm water outlet.

The sewer from the east (B), 2-ft. 6-in. x 3-ft. 6-in., egg-shaped, enters the east side north of the center. This sewer does not really empty into the tanks proper, but into the upper part of the storm water outlet. Even here, it is only overflow storm water that is discharged. The dry flow discharges into the 3-ft. sewer down Keele St. over which this Bloor east sewer passes.

The sewer from the north (C) enters the tanks at the east end of the north side. One hundred and seventy-three feet north of the tanks a weir is provided in this sewer, by which the dry flow is diverted into a 24-in. tile pipe sewer (D) leading directly into the end of the 3-ft. sewer down Keele St. This 24-in. pipe also has an overflow provided, in case at any time the 3-ft. sewer should be overcharged and back up into the 24-in. pipe. This overflow leads indirectly into the 18-in. sewer under the large outlet. The storm water from the north flows over the weir in C, 173 ft. north of the tanks, and into the tanks. Thus we see that the dry flow from all these inlets does not reach the tanks, but all discharges into the 3-ft. sewer down Keele St. on its way to the disposal



Plan and Principal Cross Sections of Reinforced Concrete Tanks for the Temporary Storage of Storm Water, Toronto, Ont.

---

*From The Canadian Engineer.

works, while only the storm water finds its way into the tanks.

Design.—The tanks are rectangular in shape, and approximately 104 ft. x 112 ft. On the north side, there is a channel 3.5 ft. deep for the Bloor west sewer, separated from the tanks by a weir. This has been described above. On the east side, there is a section 4 ft. deep, separated from the tanks by a weir, and from the storm water outlet by another weir. Into the north end of this section the storm water from the Keele St. sewer flows. The bottom of this section is graded back towards the north end and a gate valve is provided which can be opened to allow the section to drain into the storm water outlet. The tanks proper are divided into three parts, 17½ ft. deep, by two weirs. These three divisions are graded towards the east side, where they drain into an open 18-in. sludge channel, which runs south along the inner side of the east wall and into the 18-in. tile sewer under the storm water outlet. A gate valve is provided at the end of the sludge channel at the south wall.

Eight rows of columns were used in the tanks for the support of the roof. These columns were 18 in. square in section, 12 ft. apart center to center in the rows and 12-ft. centers between the rows. Two rows of columns were in each tank, and one was used as support for each of the two dividing weirs. The tanks were built of all reinforced 1:2:4 concrete. The walls were 12 ins. wide at the top, while the sides had a batter 1 in 7.6. The width at the bottom varied as the height. There was a footing provided 2 ft. deep and 12 ft. 6 in. wide. The reinforcing for the walls was 1-in. square twisted rods on the outside and 0.30 sq. in. mesh on the inside. The columns were reinforced with 1⅛ sq. in. twisted rods, 2 ft. 6 in. long, as dowels into the footing, one 1⅛ sq. in. rod in each corner, the full height of the column, and ⅜ in. round hoops, spaced vertically 12 in. apart. The roof slab was 6 in. thick, reinforced with 0.5 sq. in. mesh.

The girders and beams for the support of the roof slab were 24 in. x 16 in. and 21 in. x 16 in., respectively. They were reinforced with 1 sq. in. twisted rods and ¾ in. square twisted rods, respectively. The weir walls between the tanks were 8½ ft. high, 9 in. wide at the top, and 18 in. wide at the bottom, reinforced with ¾ sq. in. bars.

The Tanks in Action.—During a storm, the water from the north and west passes over weirs and into the tanks proper, filling the three divisions successively. When all three and section F are full, the water flows back over the weir into the storm water outlet. But this will happen only during a heavy storm, and then only when the storm is at its height. Therefore, the water passing out through the storm water outlet will be practically pure storm water.

In each of the three tanks there is a floating arm situated at the east wall, which floats on the surface of the water and collects any floating material and carries it into the 18-in. pipe under the storm water outlet. When the storm has subsided the tanks are drained, gradually, through the sludge channel into the 18-in. pipe. There is a water connection provided at the west end of each tank so that the tank may be flushed clean after it has been in use.

Construction.—The ground on which the tanks were built was composed of sand on the surface, which, in small areas, formed pockets. The subsoil was hard, blue clay. Trenches were excavated by hand for the west wall and the western third of the north wall. This part was built first because the ground was low at this side. When these walls were built, and the concrete sufficiently hardened, they were used as a retaining wall for the next material excavated. This material was taken from inside the lines of the future tanks and next the west wall. Enough material was taken out to allow for the erection of a portion of the tanks on the west side. This portion was completed floor, columns, weirs and roof and allowed to harden. The next material excavated was then deposited on the roof of this finished portion. Thus the excavation and construction proceeded alternately from the west. A clam shell was used for excavating in the body of the tanks, but the clay was so hard that the most of it had to be loosened with picks before it could be gathered up by the clam.

The concrete was all mixed by a drum mixer very conveniently placed at the top of the bank on Keele St. The concrete was dumped into a chute which carried it down the bank to a funnel-shaped box. This box was provided with a slot which slid up and down so that concrete could be taken away in any quantity desired. The concrete was carried in concrete barrows along runways so built that they might easily be taken down and erected quickly again wherever they were required. The forms used for the concrete were all of the panel type. They were built near the work and the same sections used several times. They were made before the work was begun and grouped according to size, so that when they were needed they could easily be found and quickly erected. They were fastened together with bolts.

When the work on the tanks was completed the soil which had been excavated, and soil brought from other work, was spread over the top of the tanks to a depth of 4 ft. The bank on Keele St. was extended and neatly graded, and an easy slope was made from Bloor St. The ground over the tanks and the slopes will probably be sodded and planted, and possibly tennis courts, etc., arranged on it, making in all a very great improvement to this corner of High Park.

Unit Time Data.—The time-costs, in hours' labor on this work, as kept by S. K. Ireland, B. Sc., resident engineer, are as follows:

Excavation.—7,000 cu. yd., 10,472 hours, or 1,496 hours per cubic yard.

Placing Steel.—102 tons, 1,471 hours, or 14.4 hours per ton (85 tons of this were bars and 17 tons mesh).

Building and Erecting Forms.—52,899 sq. ft. took 8,452 hours, or 0.159 hours per square foot.

Removing Forms.—0.0202 hours per square foot.

Mixing and Placing Concrete.—2,522 cu. yds. took 6,394 hours, or 2.53 hours per square yard.

Foreman, 1,658 hours; engineer, 1,098 hours; fireman, 1,133 hours; team, 107 hours; single horse, 451 hours.

MAKING A DYNAMITE THAW KETTLE FROM AN OIL CAN AND A BARREL.

By J. H. Carse.*

First: Secure an old barrel of some kind. Bore one or two ½-in. auger holes in the bottom. Next, place a little straw, hay, sawdust, or anything that will allow water to filter through easily, to a depth of about 2 or 3 in.

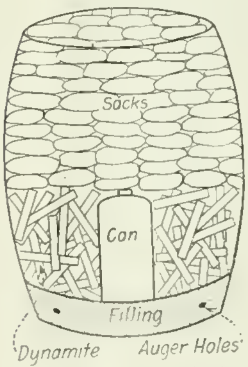


Fig. 1—Thaw Kettle for Dynamite.

Second: Secure an old oil can, capable of holding at least 5 gal. of water. A round one is preferable, because it is more convenient to pack dynamite around it. This can should have a closed top. Fill this can with boiling water, and place it in the center of the barrel on top of the 2 or 3-in. filling. The purpose of the ½-in. holes in the bottom of the barrel is to allow any water to drain out that might accidentally be spilled. In filling the can with boiling water, it is a good plan to leave an air space of about 1½ to 2 in. for the steam that will arise. In case the weather is not very cold, the can of hot water may be wrapped in a sack to prevent the dynamite from coming in direct contact with the heated metal.

Place the dynamite around the can in a manner that will allow the heat to circulate about the cartridges easily. After a sufficient quantity is thus placed, fill the rest of the barrel with sacks or anything that might be convenient which would retain the heat. In case of rainy weather, cover the barrel to keep the water out, and if a strong wind is blowing place the barrel in a lee place where the wind will not strike it. If the weather is exceedingly cold, sink the barrel in the ground. In this way the dynamite will keep in good shape for at least 48 hours, if necessary.

---

*Extract from an article in "Du Pont Magazine" for January, 1916.

A 5-gal. can of boiling water is sufficient to thaw at least 50 lb. of dynamite, but should one require a larger quantity, use a 10-gal. can of boiling water.

This plan of thawing has been proven to be a safe method. It requires 356° F. to explode pure nitroglycerin, while this method it is impossible for the heat to exceed 212° F. Tests that have been made have shown the highest temperature in the barrel not to exceed 80° F.

DATA ON THE DISTRIBUTION OF LOADS ON HIGHWAY BRIDGES WITH WOODEN FLOORS.

A comprehensive series of experiments has been carried on by the good roads section of the Engineering Experiment Station, Iowa State College, to determine the distribution of loads on highway bridge floors of various kinds. The following data on these tests are limited to a description of the methods and results obtained on highway bridges with wooden floors, the data being reported by B. S. Myers in the Iowa Engineer.

Testing Methods and Scope.—The I-beam joists were first calibrated with the aid of a Berry strain gage by placing them in a testing machine. The results of these calibration tests were then used in plotting a load distribution curve for each I-beam. The accuracy of the readings was such that a deformation of the extreme fiber due to a change of load of 100 lb. could be detected.

In the major part of this series of tests, 9-in. x 21-lb. I-beams were used, the beams being spaced about 2 ft. 3 in. apart on concrete piers built for the purpose. The test loads of 6 and 8 tons were applied by means of hydraulic jacks upon each of two typical rear traction-engine wheels. These wheels were spaced 6 ft. on centers and occupied four different positions at mid-span for each of the tests. In the first position the wheels were symmetrical about the center line of the bridge; in the second position they were shifted 1 ft. to the right of the center line; in the third position, 2 ft.; and in the fourth, 3 ft. to the right of the center line. In the fourth, or extreme position, the center line of the near wheel was 2 ft. from the edge of the bridge floor. These wheels were lifted and supported clear of the floor while a satisfactory set of no-load readings were taken with the strain gage. Then the wheels were placed in position and a set of readings were taken for the 6 and 8-ton loads above referred to. Five readings were taken on each I-beam, one reading spanning the mid-span point and two readings on each side of the mid-span point. From these readings the deformation of each I-beam at the center, due to the loads applied, was calculated; and the load carried by each of the I-beams was read from the load-deformation curves mentioned above.

Six independent sets of tests were run on the 9-in. x 21-lb. I-beams, with the following arrangement of the floor:

(1) 3x12-in. rough fir flooring, ends bolted down.
(2) 3x12-in. rough fir flooring, ends loose.
(3) 3x12-in. rough fir flooring and 2x12-in. yellow pine flooring at 30 degrees, ends loose.
(4) 3x12-in. rough fir flooring and 2x12-in. yellow pine flooring at 30 degrees, ends fastened.
(5) 3x12-in. rough fir flooring and 2x12-in. yellow pine flooring at 90 degrees, ends fastened.
(6) 3x12-in. rough fir flooring and 2x12-in. yellow pine flooring at 90 degrees, ends loose.

Results of Tests.—Figure 1 shows the distribution found for Case 1, with the wheels in the first position, and Fig. 2 shows the distribution for Case 1, with the wheels in the fourth position. These curves show a maximum of about 50 per cent of one wheel load on the I-beams near the wheels, and about 33 per cent of one wheel load on the outside channel.

It was anticipated that the position of the lugs on the tractor wheels would have a considerable effect on the distribution of the loads, and a special series of tests was therefore run to determine this effect. The greatest change in the distribution due to this cause was about 15 per cent of one wheel load, as shown in Fig. 3.

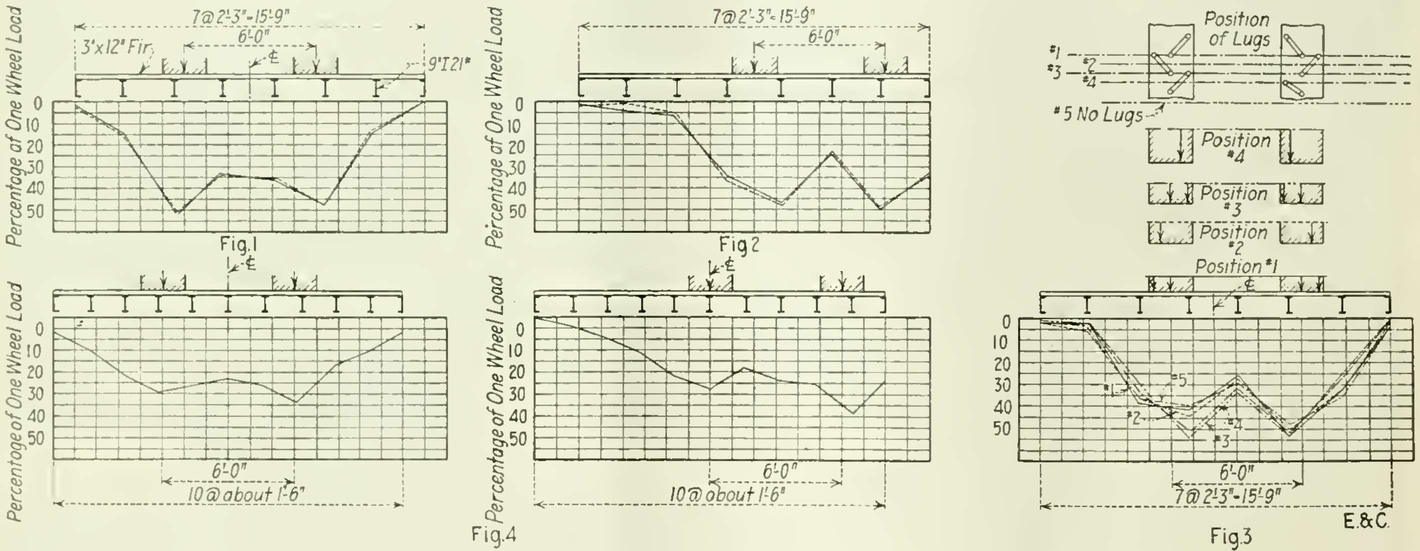


Fig.1 Fig2 Fig.4 Fig3

FIGS. 1-4—CURVES SHOWING DISTRIBUTION OF WHEEL LOADS IN BRIDGES WITH WOODEN FLOORING ON I-BEAMS.

Fig. 1—Wheels in Central Position; 3x12-In. Rough Fir Flooring with Ends Bolted Down. Fig. 2—One Wheel in Center and Other 6 Ft. from Center; 3x12-In. Rough Fir Flooring with Ends Bolted Down. Fig. 3—Effect of Lugs on Wheels on Distribution of Load. Fig. 4—Distribution of Load on Single Plank Floor with Ends Fastened Down for About 18-In. Spacing of 6-In. I-Beams for Load in Two Positions.

The floors of many highway bridges built for light traffic 20 or 25 years ago are carried on 6-in. I-beams spaced 24 to 36 in. apart. To accommodate modern traffic many of these bridge floors have been strengthened by placing a new 6-in. I-beam between each pair of beams already in the floor system. To determine the distribution of the loads and the strength of these bridge floors tests were run on 6-in. I-beams spaced 12 and 18 in. on centers and carrying a 3-in. fir floor. The distribution of loads for the 18-in. spacing of beams is shown in Fig. 4.

The curves shown are typical and show, in a general way, the distribution of loads on wooden highway bridge floors. A definite statement concerning the load distribution and assumptions to be made in designing bridge floor of this type is not warranted at present as this series of tests has not yet been completed. Complete data will be available in the form of a bulletin at a later date.

The Association of Engineering Societies.—The Association of Engineering Societies was disbanded on Dec. 31, 1915, and the Journal of the Association of Engineering Societies was discontinued with the December number. The Engineers' Club of St. Louis, the largest society in the association, and its active head for the past two years, will begin the publication of a bi-monthly journal to be known as the Journal of the Engineers' Club of St. Louis.

RECENT ADVANCEMENT IN THE CONSTRUCTION OF BRICK PAVEMENTS.*

By William C. Perkins, Chief Engineer, Dunn Wire-Cut Lug Brick Company, Conneaut, Ohio.

During the past few years, municipal and highway engineers have been investigating the integral parts of brick pavements, and endeavoring to improve each part as to design, material and construction. There are four distinct parts of a brick pavement: (1) Sub-grade; (2) foundation; (3) bedding or binder course; (4) wearing surface.

Sub-grade.—Engineers are giving considerable attention to the sub-grade of a pavement. Investigations are made as to the nature and bearing value of the soil; all springs or ground waters are taken care of; it is thoroughly rolled, and every effort is made to keep the sub-grade free of water, unyielding, of uniform density, and of proper grade and cross section. This is a distinct advancement; many of our older pavements show the results of a water soaked or badly prepared sub-grade.

For the foundation course, the engineer must design for durability and economy. The type of foundation depends therefore largely upon local conditions—climate, traffic, subsoil, availability of stone, gravel or other suitable materials. The foundation should be designed to carry the load placed upon it and should be no deeper than is necessary to do this work.

In the South many pavements are laid directly on a puddled sand sub-grade and are giving good results, but where this type of construction is used, there is no frost action and the traffic is light. Foundations of compacted gravel have proven satisfactory in Cleveland, Ohio, and other northern sections, but for general use a foundation of concrete, so proportioned that 6 cu. ft. of concrete in place will contain one bag, or 94 lb. of cement, is the foundation recommended by most engineers. Metal reinforcement is often used over an unstable sub-grade or a lately filled trench. Engineers have also discovered that the smoothness of the finished pavement depends largely upon the smoothness of the foundation, and its uniform distance below the finished contour of the pavement.

Cushion Course.—One of the greatest advancements in brick paving construction has been the elimination of the cushion of sand between the foundation and the brick wearing surface; and the substitution of a bedding or binding course, of a mixture of cement and sand, none over 1 in. in thickness. This binding course should be considered as a part of the foundation; for example, if a 5-in. concrete foundation is needed, it should be designed 4 in. of concrete and 1 in. of cement-sand.

The advantages of the cement-sand bed, and the disadvantages of the cushion of ordinary sand, have been pretty fully discussed in the technical papers and before the engineering and scientific societies. It has also been proven that many failures in brick pavements can be traced to the cushion of sand; that "resiliency" is a term which should not be applied to a brick wearing surface; that the sand cushion does shift, yield and is compressed by traffic weight, leaving small air spaces under the brick wearing surface; that air spaces under the brick surface are also caused by variations in the dampness of the sand cushion, the sand shrinking when drying. These small air spaces cause the pavement to rumble under traffic; and also become weak spots where eventually there may be a settlement in the event of the breaking of the bond between the bricks.

Laboratory tests have shown that mere weight will not crush a brick wearing surface laid on a rigid foundation, provided the bricks have an even bed.

The plain sand cushion was objectionable because of the many hazards of construction. The old specifications give elaborate directions for its compression, but engineers have found that to obtain good results in actual practice was almost impossible, and that what was generally obtained was an unstable layer of sand varying in compactness and thickness between a solid foundation and a solid wearing surface. It was also difficult to prevent the sand from working up between the joints of the brick wearing surface, and thus reducing the depth of the bond. This inequality of hardness of the material in the joints of the brick causes a shearing action, tending to crush the top of the bricks.

There has also been the hazard of weather conditions. Rain falling upon the brick before they have been rolled very often necessitates the relaying of the brick, as it is liable to undermine the cushion and wash it into the joints.

In view of these constructional hazards the engineers ask: "Why use a cushion; why not use a cement-sand bed with its many advantages?" The construction is simple —the cement and sand properly proportioned (a mixture of 1 cement and 4 sand being recommended) should be placed dry in a machine, or on a mixing board and thoroughly mixed until a uniform color is obtained. It is then spread, approximately 1 in. in thickness, on the prepared foundation, compressed with a roller weighing about 300 lb. and struck off by a template to the true contour of the pavement. If any depressions develop they should be filled and the cement-sand bed again leveled and rolled.

The bricks are immediately laid, inspected and rolled. The rolling must follow closely the laying, and all bricks laid must be rolled before the close of work. It is not absolutely necessary to apply the cement filler the same day, for the brick surface is safe from hazards of weather conditions as soon as it is rolled.

The pavement should be thoroughly wet down with a spray just ahead of the grouting. This sets up the cement-sand bed and insures an even, solid bearing for the brick and at the same time practically joins the brick wearing surface and the foundation together; and thus we have a more or less monolithic construction.

Cushionless Construction.—The theoretical monolithic construction, but one which is also thoroughly practical and easily built, is obtained by laying the brick wearing surface directly on the freshly laid concrete foundation.

The concrete foundation is finished to the proper grade and contour by means of a simple wooden tamping or striking template of the proper cross-section. This style of template can be easily moved along the side forms with a slight tamping motion, and this will bring the matrix of the concrete to the surface, and thus a smooth, even bed for the bricks, of proper grade and cross section, is obtained.

If the street is too wide to allow the use of a template for its entire width, the foundation can be formed in sections, using the same style template on guiding strips set to the proper grade, and with small stools or bridges for the men to stand upon in the finished base. The strips and stools are easily moved from place to place, and the small depressions left in the finished base can be filled and brought to proper grade and contour by hand luting.

The laying of the brick follows closely; the brick should be laid, inspected and rolled before the cement has obtained its initial set. For rolling the brick surface a hand roller about 30 in. long and 24 in. in diameter and weighing from 600 to 900 lb. should be used. The rolling should be kept close to the laying and be continued until a smooth surface is obtained. At the end of the day's work, the brick-laying, inspection, and rolling should be completed with the limit of the finished foundation.

One of the merits of this type of construction is, that the concrete foundation, laying and rolling of brick are done at the same time, thus there is a saving of time in construction, and the improved pavement is ready for traffic in much less time than under the old form of construction.

For country road work, or improvements where an edging or flush curb is used, the laying of brick directly on the concrete foundation is strongly recommended as thereby the edging or curb can be omitted, thus reducing the cost. Tests and practice have shown that the bond between the brick and foundation is amply strong to protect the edges of the roadway from the shocks of traffic.

Brick Surface.—There has also been a marked advancement in the construction of the brick wearing surface. Previous to 1910 all bricks used for paving purposes had been either plain wire cut brick or the so-called repressed brick. Engineers appreciated the advantages of the lugs on the side of the repressed bricks, but objected to their non-uniformity; objections were also made to the rounding of the edges, which made it difficult to obtain a smooth pavement. To meet these objections a wire-cut lug brick was devised, with its rough sides, square edges and uniform lugs. Its many advantages were at once recognized by paving engineers and its adoption as a paving material has been general.

---

*Presented before Section D of the American Association for the Advancement of Science at the Columbus Meeting, Dec. 29, 1915.

Recently the size of paving brick has been standardized. It had been claimed that paving bricks being made of different varieties of shales, could not be made the same size on account of the requirements of burning. The Dunn Wire-Cut Lug Brick Co. proved that this was a fallacy, the result being that the 27 or more independent companies licensed to make wire-cut lug bricks are making a standard size brick, 8½ in. long by 3½ in. wide, and which lay in the pavement 40 to a square yard. This is of considerable assistance to the paving engineer, in the making of minor repairs or for paving over "cuts."

Again the shape of the brick is changing; many bricks are still made with square ends, some containing a small circular groove; others omit the groove. The square-end bricks when laid in a pavement theoretically touch each other on a plane and do not allow for proper penetration of filler.

The standard wire-cut lug brick have a double bevel or bulge of 3-32 in. on each end. These bricks when laid in a pavement theoretically touch each other on a line at the center with an opening of 3-16 in. at the top and bottom which allows a perfect penetration of the filler. Experiments made on slabs of square end bricks, and bulged end bricks, by the state highway departments of New York and Pennsylvania, in 1914, proved that with the bulged end bricks the penetration of the filler was uniform and the bond obtained many times stronger than with the square end. The tests also proved that the small circular grooves were of little or no value, as the filler did not penetrate them.

Since the advent of the cement-sand bed, there is a tendency among paving engineers to reduce the depth of the brick wearing surface. No brick pavement has ever failed by the actual wearing away of the brick.

One thousand standard paving brick 4 in. in depth weigh 5 tons; consequently when bricks are shipped for long distances the freight charges are heavy. Standard wire-cut lug brick can be, and are being, made 3½ in. in depth, and for highway work even 3 in. in depth. These bricks having square edges insure a uniform bond the entire depth of the brick. Where local conditions warrant this reduction in depth, a considerable saving is effected in freight, haulage and material.

Special shapes are made for use on grades in order to give a foot-hold for horses. Here again there has been advancement. The old method of beveling one edge of the brick was not satisfactory. All wire-cut lug hillside brick are made with a series of shallow grooves on both faces of the brick, so that either face can be used in the pavement. These small grooves or indentations furnish a good foot-hold anywhere on the pavement for the horse, and as the grooves do not run continuously across the pavement they do not increase the traction force.

These bricks are laid longitudinally—that is, parallel with the curb or edging line. This manner of laying a pavement is a radical change but it has its advantages. The bricks follow the alignment of the street or highway and there is no "batting" required either at the curb or across the street, at angles or curves. Where this manner of laying has been used, it has proven satisfactory; but I will not prophesy if it will become general for all brick pavements—engineers are still investigating.

There has been considerable advancement in the application of the cement grout filler. The sand to be used is carefully studied, and grade specified; the amount of water to be used is determined and regulated. The use of a small batch mixer, properly equipped for grouting, is recommended for the application of the first grout. Proper boxes and squeegees are provided for the second application. Inspectors have strict orders to see that the joints are filled flush with the brick, so as to insure a smooth pavement. Traffic is regulated so as not to disturb the pavement. All this is a distinct advancement over old methods.

What about the future? There is still plenty of room for advancement. Engineers should be able to obtain mathematically the strains and stresses in a pavement, and thus be able to design a pavement as they would any other engineering structure. The use of a cement-sand bed, or the laying of the brick on the green concrete foundation, opens up a field for the economic design of pavement. The cement grout filler, while it is the most serviceable, durable and sanitary filler available, has its faults, so here again is a field for investigation. In fact, every part of a pavement—from the drainage of the sub-grade to the brick wearing surface, should be examined, tested, and investigated, and efforts made to advance if possible to such a degree of scientific assurance that there will be no such thing as a failure in construction.

VOLUME PUMPED AND COST OF PUMPING IN REPRESENTATIVE DRAINAGE DISTRICTS OF THE UPPER MISSISSIPPI VALLEY.

By S. M. Woodward, Drainage Engineer, U. S. Department of Agriculture.*

Table I shows the volumes actually pumped for four drainage districts for which careful records have been kept.

It will be noted that there is considerable variation in the relation between rainfall and amount pumped for different years on the same district, and for the different districts during the same year. The average percentage of the rainfall pumped was 40.6 per cent if based upon the total yearly rainfall, or 46.7 per cent considering only the rainfall during the months when pumping was going on. The average annual rainfall for the above four stations for all the years available was only 26.21 in., while the average annual rainfall for the Weather Bureau stations at Muscatine, Peoria, and St. Louis is 37.39 in. Assuming that the ratio would be the same, 40.6 per cent, if the rainfall were normal, we might expect the amount to be pumped as a depth of 15.18 in. Moreover, as the per centage of the rainfall appearing as run-off is usually greater during wet years than in dry ones, the above figure would more likely be less than the average run-off rather than greater. Those districts which do not have gravity sluices may well expect to do more pumping than those which have, although most of the rainfall and pumping occur at the time of the year when the rivers are high.

The cost of operation of pumping plants for drainage pumping will vary largely according to type of machinery and the method of operation. While the cost of operation of various types of machinery is well understood, the conditions obtaining on the average drainage district are likely to affect seriously the accepted cost figures. In view of this fact cost data were obtained from a number of drainage pumping plants now in operation. The operating expenses were classified under "Labor," "Fuel," "Repairs," "Supplies," and "Superintendence." Tables II and III give the cost of such items, per acre per year, for a number of districts. As some districts have a greater proportion of hill water than others, the cost has been shown for the assessable area and for the total drainage area of each district. The tables state the number of years of operation the cost figures cover, and if not otherwise stated, 1914 is the last year included. Table II is for steam-driven plants and Table III for electrically-driven plants.

It will be noted that the average yearly cost per acre of total drainage area for the steam-driven plants is $0.43, and that the variation in cost is from a maximum of $0.93 for the Coal Creek District to a minimum of

---

*Extract from Bulletin No. 304, Office of Public Roads and Road Engineering, on "Land Drainage by Means of Pumps."

$0.15 for the Des Moines County No. 1 District. Of course, great variations in the amount of water pumped and in other local conditions tend to affect the relative costs for the various plants. Where the pumps are driven by motors the average yearly cost per acre of drainage area is $0.88, with a maximum of $1.07 for the Pekin-La Marsh District and a minimum of $0.63 for the Big Swan District.

Tables II and III do not take into account the fixed charges, which include interest, depreciation, taxes, and insurance. In computing the fixed charges interest has been assumed at 6 per cent, taxes and insurance at 1 per cent, and depreciation at 6 per cent. While the rate of depreciation on the machinery might be somewhat greater than this, the cost of the machinery is only a part of the total cost of the plant, and a rate of 6 per cent is higher than would apply to the building, and especially to the foundation, the cost of which last item is often a large part of the cost of the completed plant. Tables IV and V give the total cost per acre per year for the districts given. As before, two tables are made, one for steam and one for electrically driven pumps.

It will be noted that the average yearly cost per acre of total drainage area is, for steam-driven plants, $0.78, and that the variation in cost is from a minimum of $0.40 for the Des Moines County District No. 1 plant to a maximum of $1.22 for the Lacey plant. Where the pumps are driven by motors the average yearly cost per acre of drainage area is $1.38, with a maximum of $1.89 for the East Peoria District and a minimum of $0.89 for the Big Swan District. As stated above, the amount of water pumped and other local conditions tend to alter the true relation between the costs of operation of the various plants. However, from three districts accurate and detailed records were obtained, so that the cost in operating expense of lifting an acre-foot of water 1 foot could be accurately determined. Table VI is a statement of amount pumped and the unit cost on these three districts.

Both plants on the Illinois River have a much higher mean lift than has the one on the Mississippi River. A large variation in costs is noted for the different years for the Louisa-Des Moines plant. This can be traced directly to the average lift; the pumps do not work so efficiently at the lower lift. In this respect the plants on the Illinois River have a considerable advantage over the Louisa-Des Moines plant, as their lifts are higher and the pump efficiencies must be much better. In the early part of the discussion in this section it was assumed that

TABLE I.—ANNUAL RAINFALL AND AMOUNTS PUMPED.

District.	1912			1913			1914			Total			Per cent of rainfall in run-off.	
	Rainfall.[1] In.	Rainfall.[2] In.	Run-off. In.	Rainfall.[1] In.	Rainfall.[2] In.	Run-off. In.	Rainfall.[1] In.	Rainfall.[2] In.	Run-off. In.	Rainfall.[1] In.	Rainfall.[2] In.	Run-off. In.	Rainfall.[1]	Rainfall.[2]
Louisa-Des Moines	25.67	15.07	15.15	28.16	14.84	11.32	.....	.....	.....	53.83	29.91	26.47	49.1	88.5
Pekin-La Marsh	34.49	34.49	13.41	26.05	26.05	11.80	20.85	20.85	4.87	81.39	81.39	30.08	37.0	37.0
East Peoria	.....	.....	.....	.....	.....	.....	22.75	22.75	6.98	22.75	22.75	6.98	30.8	30.8
Coal Creek	.....	.....	.....	.....	.....	.....	25.50	25.50	10.98	25.50	25.50	10.98	43.6	43.6
Average	30.08	24.78	14.28	27.11	20.44	11.56	23.03	23.03	7.61	26.21	22.79	10.64	40.6	46.7
Per cent of rainfall in run-off.	47.5	57.6	.....	42.6	56.6	.....	33.0	33.0	.....	40.6	46.7	.....	....	....

[1]Total rainfall for year. [2]Rainfall for months during which drainage was secured by means of pumps.

TABLE II.—COSTS OF OPERATION—STEAM-DRIVEN PLANTS.

District.	Number of years' operation.	Average cost per acre per year											
		Labor		Fuel		Repairs		Supplies		Superintendence.		Total	
		A[1]	T.[2]	A.	T.	A.	T.	A.	T.	A	T.	A.	T.
Nutwood	5	$0.115	$0.082	$0.158	$0.113	$0.015	$0.111	$0.038	$0.027	$0.079	$0.057	$0.405	$0.290
Eldred	1	.129	.126	.153	.150	.019	.017	.028	.027	....	....	.329	.320
Hillview	5 (1913)	.190	.126	.278	.185	.047	.031	.032	.021	.114	.076	.661	.439
Big Swan	7 (1913)	.123	.098	.250	.200	.032	.026	.031	.025	.071	.056	.507	.405
Meredosia	9	.100	.069	.314	.238	.023	.017	.020	.015	.073	.055	.530	.394
Crane Creek	4	.173	.154	.281	.250	.014	.012	.049	.043	....	....	.517	.459
Coal Creek	5 (1913)	.331	.300	.598	.540	.049	.044	.041	.037	[3].012	[3].010	1.031	.931
Lacey	4 (1905)	.072	.072	.247	.247	.030	.030	.017	.017	....	....	.366	.366
Lacey	2 (1910)	.151	.151	.416	.416	.017	.017	.027	.027	....	....	.611	.611
Spring Lake	5	.181	.103	.306	.175	.024	.014	.081	.046	.138	.079	.730	.417
Louisa-Des Moines	2 (1913)	.164	.133	.204	.165	.041	.033	.027	.022	.048	.039	.484	.392
Des Moines County No. 1	2 (1913)	.140	.053	.162	.062	.034	.013	033	.012	.036	.014	.405	.154
Average	....	......	......	......	......	......	......	......	......	......	......	......	$0.432

[1]Based on assessable area. [2]Based on total drainage area. [3]Partial.

TABLE III.—COSTS OF OPERATION—ELECTRICALLY-DRIVEN PLANTS.

District.	Number of years' operation.	Average cost per acre per year											
		Labor		Power		Repairs		Supplies		Superintendence.		Total	
		A[1]	T.[2]	A.	T.	A.	T.	A.	T.	A.	T.	A.	T.
Big Swan	1	$0.116	$0.098	$0.592	$0.473	$0.000	$0.000	$0.000	$0 000	$0.071	$0.056	$0.779	$0.627
Lacey	2	....	....	[3].740	[3].740	....	....	....	....	....	....	.740	.740
Perkin-La Marsh	3	.132	.107	[3]1.160	[3].940	.021	.018	.002	.002	....	....	1.315	1.067
Coal Creek	1	.159	.143	.860	.776	.000	.000	.010	.010	.020	.018	1.049	.947
East Peoria	1	.504	.244	1.200	.582	.001	.001	.023	.011	.372	.180	2.100	1.018
Average	....	......	......	......	......	......	......	......	......	......	......	......	$0.880

[1]Based on assessable area. [2]Based on total drainage area. [3]Cost of power calculated on basis of schedule in effect at the Coal Creek plant.

TABLE IV.—TOTAL COSTS OF PUMPING—STEAM DRIVEN PLANTS.

District.	Horsepower of engines	First cost.	Annual fixed charges.	Annual operating expenses.	Assessed area, acres.	Watershed area, acres.	Charges per acre per year on assessed area.		Charges per acre per year on watershed area.		Total charges per acre per year on—	
							Fixed.	Operating.	Fixed.	Operating.	Assessed area.	Watershed area.
Nutwood	500	$36,480	$4,750	$4,338	10,700	15,000	$0.444	$0.405	$0.317	$0.290	$0.849	$0.607
Eldred	300	28,000	3,640	3,132	9,305	9,500	.391	.337	.383	.330	.728	.713
Hillview	300	25,000	3,250	8,140	12,300	18,500	.264	.662	.176	.440	.926	.616
Big Swan	300	25,000	3,250	6,084	12,000	15,000	.271	.507	.217	.406	.778	.623
Meredosia	200	18,000	2,470	1,995	3,760	5,000	.657	.531	.494	.399	1.188	.893
Crane Creek	250	16,000	2,080	2,759	5,340	6,000	.390	.516	.347	.460	.906	.807
Coal Creek	200	16,000	2,080	6,912	6,700	7,426	.310	1.032	.280	.930	1.342	1.210
Lacey	220	15,000	1,950	1,898	5,200	5,200	.375	.365	.375	.365	.740	.740
Lacey	220	15,000	1,950	1,950	3,200	3,200	.610	.610	.610	.610	1.220	1.220
Louisa-Des Moines	500	50,000	6,500	6,280	13,000	16,000	.500	.483	.406	.393	.983	.799
Spring Lake	600	60,000	7,800	8,600	12,850	22,500	.607	.670	.317	.382	1.277	.729
Des Moines County No. 1	1,230	144,000	18,700	11,570	28,600	75,000	.654	.405	.249	.155	1.059	.404
Average	.....	....	......	......	......	......	......	......	......	......	......	$0.780

under normal conditions the average amount of water to be removed per year was a depth of 15.2 in. With the unit costs as taken from the actual operating expenses of the three plants given in Table VI, the costs of drainage per acre per year have been calculated and are shown in Table VII. In selecting the unit cost to use for the Louisa-Des Moines plant, the one corresponding to the highest head is taken, so that a better comparison can be made with the plants on the Illinois River. However, the lifts are much higher for the latter plants, thus putting them at a considerable advantage; for if their lifts were as low as that of the Louisa-Des Moines plant their efficiencies would be much decreased and the unit costs correspondingly increased. The results are calculated for average lifts of 5 and 10 ft. All three of these plants are well built and carefully operated. They are quite representative of their types, and the costs of pumping given in Table VI should quite closely approximate what might be expected in similar plants operated under like conditions.

TABLE V.—TOTAL COSTS OF PUMPING—ELECTRICALLY-DRIVEN PLANTS.

District.	Horsepower motors.	First cost.	Annual fixed charges.	Annual operating expenses.	Assessed area.	Watershed area.	Charges per acre per year on assessed area.		Charges per acre per year on watershed area.		Total charges per acre per year on—	
							Fixed.	Operating.	Fixed.	Operating.	Assessed area.	Watershed area.
Big Swan	*400	$20,000	$2,600	$10,790	12,000	15,000	$0.217	$0.960	$0.173	$0.720	$1.117	$0.893
Lacey	185	10,000	1,300	3,200	3,200	3,200	.406	1.000	.406	1.000	1.406	1.406
Pekin-La Marsh	135	7,800	1,000	3,520	2,600	3,200	.385	1.354	.313	1.100	1.739	1.413
Coal Creek	300	20,000	2,600	7,027	6,700	7,426	.388	1.049	.350	.946	1.437	1.296
East Peoria	125	10,500	1,360	1,570	750	1,550	1.810	2.093	.877	1.013	3.903	1.890
Average	.....	....	......	....	......	......	......	......	......	......	......	$1.380

*Plant has one 100-horsepower motor and 300-horsepower of steam engine. First cost estimated as if four 100-horsepower motors were installed.

TABLE VI.—AMOUNTS PUMPED AND UNIT COSTS OF PUMPING.

District.	Year.	Amount pumped. Acre-feet.	Average static head. Feet.	Cost of lifting 1 acre-foot 1 foot.
Louisa-Des Moines	1910	15,900	4.20	$0.086
Louisa-Des Moines	1911	15,000	2.82	.141
Louisa-Des Moines	1912	20,132	5.20	.064
Louisa-Des Moines	1913	16,002	5.74	.063
Coal Creek	1914	6,800	9.40	.110
East Peoria	1914	901	7.02	.158

TABLE VII.—PROBABLE COST OF PUMPING WITH TYPICAL PUMPING PLANTS.

District.	Cost of lifting 1 acre-foot of water 1 foot.	Cost of lifting 1.25 acre-feet 1 foot.	Cost of lifting 1.25 acre feet—		Fixed charges.	Total cost of pumping per acre per year.	
			5 feet.	10 feet.		Lift 5 feet.	Lift 10 feet.
Louisa-Des Moines	$0.063	$0.079	$0.395	$0.79	$0.406	$0.801	$1.196
Coal Creek	.110	.137	.685	1.37	.35	1.035	1.72
East Peoria	.158	.198	.99	1.98	.877	1.867	2.847

SUGGESTIONS ON FILING SYSTEMS FOR MUNICIPAL ENGINEERING RECORDS.*

By A. Lenderink, City Engineer, Kalamazoo, Mich.

A great many offices have in old records, maps or field books a large amount of information that would be very valuable to the office if it was properly indexed. The value of a reference book depends upon the index; this is also true of office records. Do not be afraid to cross index your subjects.

The Engineering Department at Kalamazoo has just enlarged its card index system; the material is indexed under the following general heads: Streets, Sewers, Profiles, Water, Surveys, Rivers, Creeks, Bridges, City Property, Drawings, Tests, and Miscellaneous. These are sub-divided by the use of different colored cards.

A standard size for drawings should be adopted and all drawings made to conform to it; 24x36-in. is a good size. Drawings can be made full, half, or quarter size. Maps and drawings that are made on odd size pieces of paper are usually thrown into some drawer and left. Odd size drawings can not be filed easily, or so as to economize space.

The city of Kalamazoo has adopted the section as the unit for city detail maps. These are drawn to a scale of 200 ft. to the inch. A separate set is used to show the location, depth, size and grade of sanitary and storm sewers, one for water mains showing size and location, one for telephone and light conduits and one for street monuments and bounds; the page of the record where the references to the monuments may be found is marked in red ink on the maps.

The city of Grand Rapids uses a very good method for the filing of street profiles. They are drawn on mounted profile paper 17 by 30 in. to a scale of 100 ft. to the inch horizontal and 20 ft. to the inch vertical. These sheets are then bound in book form. This binding may be either permanent or loose leaf.

Each office must select a method best suited to its own needs.

THE PER CAPITA CONSUMPTION OF WATER IN THE PUBLIC SCHOOLS OF HARTFORD, CONN.*

By Caleb Mills Saville, Chief Engineer, Board of Water Supply, Hartford, Conn.

The total use of water in the schools of Hartford, Conn., amounts to about 37,500,000 gal. per year or about ¾ gal. per capital of estimated population. Of the schools using water there are 20 public schools using 18,800,000 gal. per year and 14 parochial schools using 9,700,000 gal. for the same period. The total number of children of school age is estimated as 24,456. The school year extends over 40 weeks from the Friday following the second Wednesday in September, comprising about 210 actual school days.

Table I gives data on the consumption of water in the public schools of the city, the attendance being taken from the report of the Board of School Visitors of the city of Hartford for the year 1914.

TABLE I.—WATER CONSUMPTION IN HARTFORD PUBLIC SCHOOLS.

District.	Total average attendance			Total mil. gal. per year.	Gal. per capita, attendance per school day.
	Pupils.	Teachers.	Total.		
Brown	1,589	47	1,636	2.66	7.75
South	4,182	144	4,326	3.52	3.88
Second North	1,380	54	1,434	1.25	3.74
West Middle	958	44	1,002	.86	2.61
Arsenal	1,514	58	1,572	.50	1.52
Washington Street	1,177	45	1,222	.88	3.32
Southwest	243	13	256	.35	6.49
Northeast	1,211	46	1,257	1.63	6.68
High School	1,823	104	1,927	6.29	15.57
	14,077	555	14,632	17.94	5.84

The average consumption per pupil in the public schools is 3.5 gal. per day per calendar year.

---

*Paper read before annual meeting of Michigan Engineering Society.

*From a paper read before the New England Water Works Association.

Engineering and Contracting

Devoted to the Economics of Civil Engineering Design
and to Methods and Cost of Construction

EDITORS
H. P. Gillette C. S. Hill C. T. Murray S. C. Hadden C. W. Malcolm

Volume XLV. CHICAGO, ILL., FEBRUARY 2, 1916. Number 5.

ENGINEERS AND OTHER EXPERTS FROM A NEWSPAPER STANDPOINT.

In an editorial entitled "Engineers and Other Experts," in its issue of Jan. 25, 1916, The Daily News of Chicago says in part:

> Speaking generally, the public should be on its guard against the tendency to force it to employ men technically called engineers where experts of different training may serve it better. Engineers get most of their employment from private interests. It is difficult, therefore, to secure engineers of large practice who will be vigorous defenders of public rights in controversies between the public on the one side and public service corporations on the other.

The editorial in question was inspired by the removal of Professor Bemis as a member of the Chicago traction board by Mayor Thompson, on the grounds that the former is not an engineer. Mr. Bemis, although not trained as an engineer, has continued as the city's representative on the traction board since his appointment by former Mayor Harrison, even though the traction settlement ordinances state that the city's representative shall be an engineer. The Daily News, in taking exception to the removal of Mr. Bemis, says:

> Certainly Mr. Bemis by this time has gained a familiarity with the problems under consideration which a new appointee will need some time to acquire. It therefore seems unfortunate that an existing arrangement which is giving satisfaction should be suddenly overturned for no other reason than that it may be open to objection on technical grounds.

The following interpretation of the term "engineer" by The Daily News is interesting, especially in view of the fact that engineers themselves have found difficulty in defining the term satisfactorily:

> As it is used today, the term "engineer" has a broad application and is often given to men of the requisite high ability in certain lines, even though they have not been given engineers' diplomas in the mechanical, electrical or like professional schools.

The Daily News admits the traction settlement ordinances specify that the city's member of the board of supervising engineers shall be an engineer, but states that Mr. Bemis "has acted many times in capacities where men of engineering experience were needed." In concluding its editorial The Daily News argues that the questions involved are not by any means all engineering in their nature, and that highly skilled and experienced men without engineering training are able to give the public much better service on many of these questions than are men of training in technical and engineering schools.

In view of the fact that The Daily News has a wide following, due largely to its conservative and generally constructive policy, we deem it necessary to call attention to certain features of this editorial which we consider are apt to mislead its readers and to prejudice them against engineers.

In the first place, we maintain there should be no criticism of Mr. Bemis' removal, as the traction settlement ordinances clearly state that the city's member of the board of supervising engineers shall be an engineer, and Mr. Bemis has not been trained as an engineer. The fact that he has been permitted to act "many times in capacities where men of engineering experience were needed" is certainly no justification for his retention if he is unable to qualify as an engineer. It might as well be argued that the mere holding of a public position by a political appointee who is entirely unfamiliar with the work justifies his retention in that position.

Secondly, the problems to be met and solved in this case are chiefly engineering in character, and as such can best be solved by a trained engineer. The contention of The Daily News that the "problems involved are not by any means all engineering in their nature" carries little weight, as it is a general statement which might be said of almost any position in which the engineer is called upon to serve. Certainly few would seriously argue that the trained engineer of today does not possess sufficient general education and ability to enable him to solve problems other than those entirely engineering in character.

With reference to The Daily News' interpretation of the term "engineer" we are compelled to acknowledge that a newspaper could hardly be expected to have a clear conception of the term when engineers themselves are unable to agree as to definition. There is at present a tendency on the part of some engineers to classify as engineering many lines of activity which are not engineering at all. Engineers must face the fact that engineering has some limitations and that the successes of some prominent engineers in other kinds of work are due not so much to their engineering knowledge and training as to other natural and cultivated abilities. However, The Daily News' assertion that the term is often given to "men of requisite high ability in certain lines, etc.," is indeed indefinite and meaningless.

The chief cause for resentment on the part of engineers is contained in the statements quoted at the beginning of our editorial; these we assert are not only uncalled for, but are unfair and generally without merit. The success with which engineers have long filled municipal positions of trust, and the almost entire absence of charges of any kind affecting their honesty in serving the public, should be sufficient evidence that engineers can well be trusted to safeguard public interests. The statement that engineers get most of their employment from private interests is, we assert, no more true of engineers than it is of other professional men whom the city might engage. However, we do not care to argue this point, as it is immaterial in any case. It certainly does not follow—as is claimed by The Daily News—that "it is difficult, therefore, to secure engineers of large practice who will be vigorous defenders of public rights in controversies between the public on one side and public service corporations on the other." Such an assertion is ridiculous, and vicious, as its evident intent is to lower the standing of engineers in the eyes of the public and thus deprive the latter of the kind of service for which the engineer's training particularly fits him. We agree with The Daily News that what the public desires is service, and it is on this ground that we ask for the appointment of an engineer to fill the vacancy left open by the removal of Mr. Bemis. The editorial in question is but another indication that engineers have much work yet to do before the public and its organs are educated to a full realization of the value and extent of the service which the engineer is capable of rendering.

SUCCESS OF THE ACTIVATED SLUDGE PROCESS SEEMS ASSURED.

The treatment of sewage by forced aeration in the presence of activated sludge is rapidly emerging from the promising to the established stage. The critical period —the first period of intense cold—has been safely passed, both at the Milwaukee and the Urbana experimentation plants. These plants continued to perform their functions during the cold weather with but slight variations from normal. It is safe to say that the cold weather ghost has been laid. Of equal importance is the firm conviction of the experimenters that the process is economically practicable for cities having a daily average sewage flow in excess of two and perhaps of one million gallons. In view of these two facts of major importance the success of the method seems assured.

Of course there are many small wrinkles yet to be ironed out before the average practitioner should adopt this method as one of his working tools. The experimenters continue to learn things which will have an important influence on the arrangement and proportions of a plant utilizing the newly discovered principle. Early conclusions continue to be modified and this is to be expected throughout a considerable period of development.

Meanwhile it is desirable to study the results secured by the experimenters, and in this issue we publish an article which brings the Milwaukee experiments down to date. The article summarizes all the Milwaukee work, and gives the latest results and tentative conclusions.

THE ROAD SCHOOL BECOMES AN INSTITUTION.

To assert that the road school has become an institution is perhaps going beyond the facts strictly speaking, but its development and persistence gives more than bare excuse for such assertion. No count has been kept of the notices that have come to the editor's desk during the past few weeks but recollection permits a fairly complete summary. To be brief, short courses in highway engineering have recently or will soon be conducted at the universities of Purdue, Cornell, Michigan, Illinois, North Carolina, Tennessee, West Virginia, Kentucky, Pittsburg and at Iowa State College, Maryland Agricultural College and the University of Wisconsin by the Wisconsin Highway Commission. Doubtless there are other schools whose names we have missed but the number listed demonstrates the wide adoption by our state universities of the short special course in road engineering.

The road school has now become sufficiently common and familiar not to be longer misleading as to purpose and value. At first this was not wholly true. There was a belief that a course in one of these schools made in a few days or weeks a competent highway engineer. Knowledge of this belief by engineers really trained in road design and construction led them to regard the road school unfavorably. The road school is no longer held, even by the unsophisticated, to be a training school for highway engineers. Rather it is known for what it really is a practically gratis means of popular education in the elements of road building. As this, the road school is serving a very good purpose and deserves commendation.

WATER ENGINEERS SHOULD STUDY FIRE UNDERWRITERS' PROPOSED STANDARD SCHEDULE FOR GRADING CITIES.

There was recently issued a small book entitled: Proposed Standard Schedule for Grading Cities and Towns of the United States. It was written by the engineers of the Committee on Fire Prevention of the National Board of Fire Underwriters. It has been tentatively adopted by the Actuarial Bureau Committee with the consent and approval of the Executive Committee of the Board. The Board holds that it would be unwise to promulgate this schedule for use by rating organizations until it has been thoroughly tested by application to a large number of cities and towns having varying conditions as to all of the points of grading contemplated by the schedule. It is further appreciated by the Board that in the absence of such thorough test grave injustice might be done to a number of cities and towns. If it is found that the schedule needs correction in any particular, and this, of course, is expected, the subject will have the further attention of the committee.

Knowing the interest of water works men in this subject, we sought permission to publish that portion of the schedule which relates to Water Supply. Permission so to do was withheld because each section of the schedule was felt to be so closely related to the other that the book should be published in its entirety or not at all. This we could not undertake because of space limitations and because fully 60 per cent of the schedule is of no interest to the readers of this journal. In our correspondence with Mr. W. E. Mallalieu, general manager of the Board, 76 William St., New York, he stated that the "schedule is put forth for trial, for discussion and study, and we hope to receive valuable comments from those who have an opportunity to read it."

The grading schedule is based upon the plan of assigning to the various features of fire defense found in cities of the United States, points of deficiency depending upon the extent of variance from standards formulated from a study of conditions in more than 300 cities; the natural and structural conditions which increase the general hazards of cities, and the lack of laws or of their enforcement for the control of satisfactory conditions, are graded in the same way. The sum of the maximum points of deficiency totals 5,000 and is divided in accordance with the relative values of the features considered as follows: Water supply, 1,700 points; fire department, 1,400; fire alarm, 550; police, 50; building laws, 200; explosives and inflammables, 200; electricity, 150; and natural and structural conditions, 750. Thus, under the heading Water Supply, the schedule outlines the ideal elements of a water supply, pumping, and distribution system from the fire protection standpoint. Points of deficiency are assigned, item by item, for variations from the ideal.

The water works engineers of the country should study this grading schedule with a view to safeguarding the interests of the owners of water utilities. Advantage should be taken of this opportunity to clear up some of the doubtful points in the relation between local fire insurance rates and the character of the local water works installation. We suggest that this whole matter be gone into very carefully at an early date. Perhaps the water works associations will find it worth while to appoint a joint committee on the fire protection requirements of water systems to confer with the engineers of the National Board of Fire Underwriters before a standard grading schedule is finally adopted and promulgated for use by rating organizations. The matter is open for discussion at this time.

EVALUATING THE BENEFIT OF FLOOD MITIGATION.

A month or so less than three years ago a devastating flood swept the river valleys of Ohio. Since then the public mind has concentrated on stream regulation in one of its phases—mitigation of floods—to the practical exclusion of all other phases. The sudden losses due to flood in 1913 in a large degree effectually blinded all to every other phase and purpose of stream regulation but protection from floods. This assertion is not offered in censure of the people of Ohio but in illustration of a prevailing human tendency to magnify the importance of the occasional disaster as contrasted with prevailing and continuous slow waste. The thought is suggested by a recent Ohio State University Bulletin in which Professor C. E. Sherman, civil engineer, discusses the Ohio Water Problem.

Stream regulation, engineers generally concede, should take into account several things besides flood mitigation. The possibilities of navigation and of water power are two of these other things. Still others are water supply and waste dilution. These values of stream regulation as stated are generally conceded, but they have seldom been definitely equated. Professor Sherman equates them for Ohio streams as follows: 50 per cent navigation, 20 per cent water power development, 20 per cent flood mitigation and 10 per cent sanitation, municipal and industrial water supply and miscellaneous benefits. These are values which we shall not attempt to verify; they are quoted here merely to inculcate the lesson that in evaluation in specific terms lies the only true understanding of the benefits of stream regulation. Engineers and engineering associations who have set themselves the task of interesting the people in the conservation of our internal waters need to bear heavily on this feature. Otherwise public opinion will swing to all sides in turn as the pressure of one or another of the possible benefits assumes preponderance.

A GOOD ROADS EDUCATIONAL MOVEMENT BY MOTOR TRUCK MAKERS.

The influence of the automobile on road design and construction and maintenance has reached nearly the limit of discussion. The part played by the automobile in creating public sentiment in favor of road improvement has been almost as widely published. In all this publicity work the automobile maker has assumed a prominent position, and though his motive has been primarily to open wider markets he can be willingly credited with a great general good accomplished toward a better road transportation system. The work of promotion has now arrived to the motor truck builder and recent investigation made in his behalf opens up a wide field for improvement.

According to statistics collected by the Garford Motor Truck Co., from 3,440 dealers less than 10 per cent of our public roads guarantee the economic or dependable use of the motor truck. It is true probably that this moderate mileage is located in large part where haulage by motor truck gives the greatest opportunities, but with its advantage this fact contains a disadvantage. It has concentrated demand for motor trucks. In response production facilities have doubled and tripled, and the visible demand will soon be filled. The motor truck maker is somewhat in the position of the man all groomed and dressed to go out and with no place to which to go. Hence we find an anxiety being manifested by motor truck builders to give additional impetus to good roads propaganda.

At present activity is confined to individual manufacturers, but the time will not be long before concerted effort is brought about. When this occurs a very powerful means of arousing good roads sentiment will be in action. On the whole this will be a beneficial thing. This journal has not been among those who have feared the growth of the good roads sentiment into a craze for unlimited expenditure. That disaster will never arrive because of a number of very good reasons. A good roads educational movement by motor truck makers merits approval.

THE VALUATION OF WATER WORKS PROPERTIES.

X. The Rate of "Fair Return."

By Halbert P. Gillette.

Public service commissions have adopted the expression "rate of fair return" to denote the percentage of annual net operating revenue allowed by them upon the appraised value of a public utility property. The "net operating revenue" is the balance remaining after deducting from gross operating revenue the operating expenses, taxes and depreciation annuity.

Public service commissions have commonly allowed 6 to 8 per cent as a "fair return rate." Few decisions have indicated that much study has been given to the subject of the "fair return rate." The Wisconsin Railroad Commission analyzes the rate into two elements: (1) The interest rate and (2) the profit rate. Thus a 6 per cent interest rate plus a 2 per cent profit rate give an 8 per cent "fair return rate." The profit (2 per cent) presumably covers risk and leaves a margin for what may be called proprietary reward.

Adam Smith in his "Wealth of Nations" (written about the time of our Revolutionary War) speaks of the normal "profits" of manufacture, merchandising, etc., as being double the normal interest rate, or about 12 per cent, but he used the word "profit," as many people still use it, to include a normal interest on the investment.

A rate of fair return may be analyzed into three elements:

1. Interest on well secured capital.
2. Insurance against risks covered neither in the operating expenses nor in the interest.
3. Reward for proprietary supervision.

Ordinary interest rates contain at least some insurance against financial risks, but this insurance is relatively slight in the bonds of large, well established companies.

A 4.5 to 5 per cent interest rate usually includes comparatively little risk insurance and very little proprietary supervision.

Risk insurance should always be considered in connection with the depreciation annuity, although the two rarely have been viewed together as parts of our whole. A depreciation annuity, as was pointed out in the second article of this series (June 2, 1915), is largely an insurance against obsolescence and economic inadequacy. Hence if little or no provision is made for these factors in the form of a depreciation fund, it follows that the "rate of fair return" should be made correspondingly greater. Almost without exception, however, this important matter has been disregarded in establishing rates of "fair return." The same rate has repeatedly been applied to two similar companies, one of which set aside a liberal depreciation reserve while the other provided no reserve at all.

It has often been said that the element of risk is largely eliminated under public regulation of rates. But this is not true. In nearly every state the municipalities are free to build competing plants, and they often do so. Wars and other causes of "hard times" continue to make every business somewhat hazardous. Then there is the ever present hazard of poor management. Let bad judgment be used in making additions to or changes in the plant, and much of the profit may be absorbed in "development cost," leaving little or nothing for dividends. Against these and other risks the public guarantees nothing. The rates paid for the service are assumed to provide the insurance. It is true that rates found to be inadequate may be raised, but the public ill-will that usually follows a rise in rates is often very costly to a company, even where it is practicable to increase rates.

Every water works, and indeed every other public utility plant, that has been properly designed for a growing community, is more than adequate for its present needs, in at least some of its parts. This is inevitable, for the engineer plans not merely for today, but for several years in advance. Let something occur to reduce the rate of growth considerably and it will often be found impracticable to charge rates that will yield a "fair return" on the entire investment until the old rate of growth is resumed. There are not a few water works systems that are badly "overbuilt"—too large for the present population—and they do not and can not yield a "fair return." To insure against such risks as this, a higher rate of return must be provided for water works in general.

A common sophistry is found in the arguments of those who hold that 6 per cent is a "fair return rate" in the case of old and successful companies, even if not sufficient in the case of new companies. This sophistry is perhaps best exposed by showing what would happen were the securities of all utility companies owned by one company or person. Then, it is clear, the deficits in fair return suffered by the unfortunate companies would have to be counterbalanced by the surpluses earned by the remaining companies, else the total net income would fall short of being a "fair return." Wherever the item of insurance rate enters an economic problem, it must be applied as an annual percentage to a large number of similar units. Hence if the rate of "fair return" includes insurance against certain risks, as it should, it is manifestly unsound to confiscate the risk insurance in the case of a financially successful company by reducing its rate of return.

Although the element of risk insurance may be discussed by itself, it is closely associated with the third element in the "fair return rate," namely the reward for proprietary supervision, that is the reward to the owners of the property for exercise of judgment and the courage of their convictions. In nearly every utility company there is at least one stockholder upon whose judgment a very great deal depends. He is the financial leader to whom men are attracted because of his recognized ability at making his investments "make good." He may not be, and often is not, the active manager of the company, but he frames its larger policies and he directs their execution. Associated with him are other investors, and his financial power usually depends largely upon them. Such a leader, if successful, is unquestionably entitled to reward. He must share the reward with his financial associates, else they will flock to other leaders. The reward is the profit in excess of normal interest, and it is, of course, so intertwined with the risk insurance element as not to be precisely separated.

I am satisfied that altogether too much stress has been put upon the risk element and too little upon the proprietary reward element in discussions of fair return rates. That a stockholder should be rewarded for what appear to be entirely the acts of other men has not seemed equitable. Whether it is ideally equitable or not is hardly germane. The election of public officials, for example, is not an ideal process of selecting such officials. We may well form ideals, but we should not hastily condemn all that fails to fit the mold of perfection. So, while it may not be a scheme without flaw to reward all stockholders because some few greatly merit reward, we can not escape doing so as long as the financial world is as it is. Furthermore, let us beware of denying merit to the man who is merely capable of discovering merit. The little stockholder who sees in James J. Hill a great railway man is perhaps entitled to reward for so seemingly small a thing as his vote of confidence. At any rate, the time has not yet come to declare the stock company system of co-operative risk and profit a failure. It continues to bring to the front a goodly supply of strong men, who, with all their frailties, are seemingly the fittest to lead.

If proprietary reward (that is profit to the owners in excess of say 6 per cent) were entirely eliminated from the "fair return" allowed public utilities, no one can doubt that the oldest financial leaders would abandon the public utility field almost entirely. I know several who have done so in the past few years, and I know more who plan to enter new lines of business. The limitations upon profits, more or less arbitrarily fixed by public authorities, have seemed too severe to them, and they prefer fields that offer greater rewards.

Capital follows executive ability. Executive ability is not, as many think, mere skill in controlling employes. Executive ability is that and more. The great executive is a man of imagination and of courage. He sees beyond the window sill, and he dares to fare forth even where others have signally failed.

So, I believe, a profound mistake is made when proprietary reward is not liberally included in the "fair return" allowed upon public utility investments. Bold and capable owners of utility plants can do vastly more toward the ultimate reduction in rates of charge than can the most parsimonious rate-regulating commission.

In a small plant, such as a water works serving a little city, the proprietor often draws little or no salary, but looks to the dividends on his stock for his main compensation, even though he devotes considerable time to the general management of the plant. Where this is the case the rate of fair return should far exceed the ordinary allowance of 7 to 8 per cent. Moreover, it should be remembered that the risk insurance element is usually greater for a plant serving a small city than for one serving a large city. The closing down of a few large industries in a small city may seriously reduce the net earnings of a utility plant that serves them. The higher rate of interest that small companies pay on their bonds indicates, in part, the greater risk involved.

In establishing what a rate of fair return should be it is customary to show, by the testimony of local bankers and real estate men, what the prevailing rates of interest on mortgages are. Also it may be shown that such a business as banking itself commonly yields a return of 8 per cent or more on the invested capital and surplus. True, the average "return" earned by national banks in America has exceeded 9 per cent for many years.

It is also well to establish what the normal "profits" from various classes of business enterprises are. To do this some well-known auditing firm may testify as to their experience, and without naming individual cases may submit lists of examples of "profits" normally earned by various classes of companies whose books have been audited by them.

A rate of fair return for a public utility company should be one that will attract new capital for additions and improvements. If the rate is too low capital will flow into other fields. But, although it is common to speak of capital as if it were a thing impersonal in the extreme, money is, in fact, an order to command labor; and the commission to execute the order is virtually given to some capitalistic leader. As previously stated, it is of prime importance that the leader be progressive. Capital will doubtless flow at low rates into long established, conservatively managed businesses in old communities, but the fact that it does so is no evidence that low fair return rates should be fixed. Better far, for the sake of ultimate low unit cost, is a higher rate of return that will fire the imagination of a progressive financial leader. Under the guidance of such a man business can be made to thrive and, thriving, the unit charges for product or service will decrease almost automatically.

It is fast becoming evident that there are grave defects in the plan of allowing only a fixed rate of return on the cost or value of a plant. Proprietary brains deserve reward not for what is expended in plant construction, but for what is saved. Ultimately, perhaps, a normal interest rate of say 6 per cent will be allowed upon the investment in a utility plant, plus a profit that rises as the unit charge for the service to the public falls. The sliding scale of dividends allowed to certain gas companies, as in Boston, illustrates the trend toward a more rational rate-making theory. For each 5 ct. per thousand in the price of gas, the dividend rate on the stock is permitted to rise a stated fraction of 1 per cent.

Some years ago I suggested the plan of periodic rate fixing, under which the rates of charge would not be lowered by public act for a term of years, and during which a company would be like the owner of a patent, entitled to earn all that could be earned. Recently the rates of the New York Telephone Co. were fixed by the public service commission for a period of three years. While this is much too short a period in most cases, it illustrates the point and may forecast a trend.

A HISTORY OF THE THERMOMETER; AGITATION FOR ADOPTION OF THE CENTIGRADE SCALE AS STANDARD.

Contributed by Ernest McCullough, Consulting Engineer, Chicago, Ill.

The Hon. Albert Johnson, of Washington, has introduced in Congress a bill to provide for the abandonment of the Fahrenheit thermometer and the use of the Centigrade thermometer by all departments of the United States Government. He asks that all scientific and technical men throughout the United States write their Representatives and Senators in Congress as soon as possible and urge that the change be made. He asks also that all the scientific and technical societies pass resolutions to the same effect and send them to the Thermometer Committee, A. A. A. S., Washington, D. C. It is necessary that the work be done promptly and the following history of thermometric scales is given for the information of those who will care to interest themselves in the change from a hap-hazard, empirical thermometric scale to a sensible and really scientific scale.

The letters and resolutions should ask that the change be accomplished as follows: Any department of the Government may adopt the Centigrade scale in its work and publications at any time but the change shall be compulsory in all departments after Jan. 1, 1920. Until Jan. 1, 1925, the Fahrenheit equivalent shall appear in parenthesis following the Centigrade temperature, but after that date the Centigrade temperature alone shall be used. The Centigrade temperatures are at present those used by scientific men in every country of the world and are used in the physics and chemistry classes in all high schools and colleges. The change, therefore, will merely apply to common use.

Beginning about the year 1680 the literature of science became international and common measures and weights were seen to be desirable. In 1793 the French Government adopted the metric system of weights and measures, this system now being that of scientific men and used as the official system in practically every country except those where the English language is the language of the people. With the metric system of weights and measures the French adopted the scale of Celsius for thermometers, naming it the Centigrade, because of the decimal division of the scale.

Gabriel Daniel Fahrenheit, a native of Danzig, in Germany, long a resident of Holland and England, attempted to make a temperature recorder and first sought for a zero point. He made a saturated solution of salt and placed in it a sealed glass tube containing alcohol. This he succeeded in freezing during the winter of 1709, on the day of the coldest recorded temperature in Holland. After marking the top of the alcohol in the tube the instrument was warmed in the hands of several persons and the highest average point reached by the liquid was taken as the normal blood heat and marked 100, the scale being graduated uniformly between those points and continued considerably higher. It was discovered that at very low temperatures and at very high temperatures the expansion and contraction of alcohol was not uniform. It was discovered also that the specific gravity of the liquid was important so that thermometers made by different men did not agree. Fahrenheit was an instrument maker and a careful experimenter so he went about the discovery of a better liquid in a careful painstaking manner.

About 1714 he learned that mercury expanded uniformly at practically all temperatures and constructed a bulb thermometer containing mercury. Setting it in a mixture cooled to the zero of his alcohol thermometer he carefully measured the volume of the mercury and found it contained 11,124 units. Raising the temperature to that of melting ice the volume increased to 11,156 units, an increase of 32, which he marked as freezing point. Placing the tube in water which was brought to a boil the volume increased to 11,336 units, a further increase of 180, making a total of 212, which graduation was then representative of the temperature of boiling water. Being a prominent member of the Royal Society of Great Britain that society in 1720 succeeded in securing the adoption of the Fahrenheit scale by the British Government.

Rene Antoine Forchault de Reaumur, a native of La Rochelle, in France, long resident in Paris, believed the arbitrary zero of Fahrenheit was clumsy and unscientific and difficult of restoration, so adopted as his zero the freezing point of water. He used spirits of wine of such a specific gravity that a volume of 1,000 parts at the freezing point of water expanded to 1,080 parts when the water boiled. His scale therefore was graduated into 80 parts between the freezing and boiling points of water. It is in fairly common use in parts of Russia, Germany and Spain today, although the scientific men and manufacturers in those countries use the Centigrade thermometer, and this latter is the official Government scale. The Reaumur thermometer appeared in 1731, eleven years after the adoption of the Fahrenheit scale by the British Government.

In 1742 Anders Celsius, professor of astronomy at Upsala University, Sweden, constructed a thermometer in which the freezing point of water, frost point, was zero, following the example of Reaumur. The boiling point of water, however, he fixed at 100, hence the name Centigrade later applied to his thermometer, which is yet called the Celsius thermometer in some countries. Any experimenter may determine the freezing point of pure water and also the boiling point. Any hollow tube with uniform bore may be used and any liquid may be used which expands at a practically uniform rate. It is thus easily possible to reproduce thermometers in case standards are lost. The graduations are larger than those on the Fahrenheit scale, which is a convenience. To hold to the Fahrenheit thermometer based on unscientific, empirical measurements is not creditable to an intelligent people and as the Centigrade thermometer is in universal use it is time all English speaking countries fall in line with other countries and adopt a universal designation of temperature. Intercourse with other nations will be facilitated and conversion tables will be done away with. The present way of mentioning temperatures, with three thermometers in use is prolific of mistakes.

THEORETICAL DETERMINATION OF THE BENDING MOMENT AND DEFLECTION IN COLUMNS SUBJECTED TO COMBINED BENDING AND COMPRESSION.

Contributed by David Kaplan, C. E., Public Service Commission, New York City.

In this article there are developed the true theoretical expressions for the bending moment and deflection in columns for the most frequent cases of combined bending and compression met in practice.

Case 1. Column Subjected to Axial Load Alone.—Let Fig. 1 represent a column, free at its ends and subjected to an axial load W; also let y represent the deflection due to the load W placed at a distance x from one end of the column.

Equating y to some unknown power of x we may write, for the deflection at any point in terms of x,

$$y = x^n \quad \dots\dots (1)$$

Denoting by l one-half the column length, the maximum deflection at the center is l^n; and, since the condition of deflection in the column is symmetrical about this point, equation (1) is the same for either half of the column at any distance x from the corresponding ends.

Therefore, we may write for the bending moment Wy at any point in either half of the column, in terms of x,

$$M = EI \frac{d^2y}{dx^2} = Wx^n \quad \dots\dots (2)$$

Integrating twice and noting that $y = 0$ when $x = 0$, also that $\frac{dy}{dx} = 0$ when $x = l$, we get the following expression for the maximum deflection l^n in terms of W, E and I:

$$y = l^n = \frac{Wl^{n+2}}{EI\,(n + 2)} \quad \dots\dots (3)$$

Solving equation (3) for n, and substituting its value in equations (1) and (2), we get the two following expressions for the bending moment and deflection respectively, these being the same for either half of the column:

$$M = Wx^{(Wl^2 \div EI)-2} \quad \dots\dots (4)$$

$$y = x^{(Wl^2 \div EI)-2} \quad \dots\dots (4a)$$

In equations (4) and (4a), when $(Wl^2 \div EI) = 3$, n equals 1, and the condition of bending becomes identical with that of a concentrated load applied at the center of a simple beam with free ends, producing a reaction at each end equal to W and a deflection theoretically equal to l, one-half the length of beam.

That the above is true may now be fully verified by the maximum deflection formula for a concentrated load at the middle of a simple beam with free ends, which is $\frac{PL^3}{48EI}$. Remembering that $P = 2W$ from the above discussion, also that $L = 2l$, and putting the value $\frac{Wl^2}{EI} = 3$, as reasoned above, the value for the maximum deflection becomes equal to l or L/2, which is the same as that of the column when $\frac{Wl^2}{EI} = 3$.

Case 2. **Column Subjected to an Axial Load and to a Horizontal Concentrated Force at Its Middle.**—Let the column with its end conditions as before now be subjected both to an axial load and to a horizontal force P at the middle. The expression for the bending moment in either half of the column now becomes:

$$M = EI\frac{d^2y}{dx^2} = \frac{P}{2}x + Wx^n \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad 5)$$

Integrating twice as before, and noting that the maximum deflection for both an axial and a concentrated force occurs at the middle, we have $\frac{dy}{dx} = 0$, when $x = l$, also $x = 0$ when $y = 0$, and the expression for the greatest deflection of the column becomes:

$$y = l^n = \frac{Pl^3}{6EI} + \frac{Wl^{n+2}}{EI(n+2)} \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (6)$$

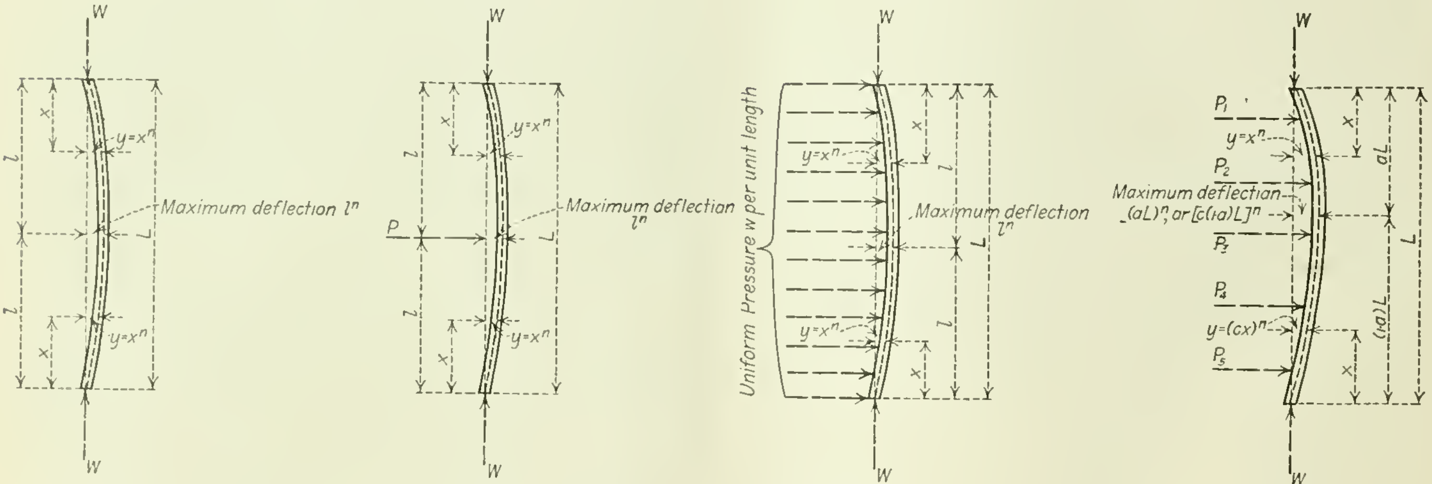


Fig.1 Fig.2 Fig.3 Fig.4

FIGS. 1-4—DIAGRAMS ILLUSTRATING FOUR CASES OF COLUMN LOADING CONSIDERED IN DERIVING FORMULAS.
Fig. 1—Axial Load Alone. Fig. 2—Axial Loao and a Horizontal Concentrated Force at Center. Fig. 3—Axial Load and a Horizontal Uniform Pressure. Fig. 4—Axial Load and Any System of Horizontal Forces.

in which the first term is the deflection of the column due to the concentrated force P, which is identical with the expression $\frac{PL^3}{48EI}$ since $L = 2l$, and the second term is the deflection due to the axial load W. Since the latter is no longer equal to the total middle deflection l^n (as it is in Case 1) the expression for n cannot be found in the same manner as before. Recourse will therefore be had to the "principle of work." The expression for the maximum deflection at the middle due to W alone can accordingly be written:

$$f_w = \frac{2}{W}\int_o^l \frac{M^2dx}{EI} = 2\int_o^l \frac{Wx^{2n}\,dx}{EI} = \frac{2Wl^{2n+1}}{(2n+1)EI} \ldots (7)$$

Expressing the first term of equation (6) in terms of l, or $f_p = kl^n$, and solving for k, we get:

$$k = 1 - \frac{Wl^2}{EI(n+2)} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (8)$$

Equating the two expressions for f_w from equations (6) and (7), and solving for l^n, we get:

$$l^n = \frac{l(2n+1)}{2(n+2)} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (9)$$

Since f_p equals kl^n, we have by substitution:

$$k = f_p\frac{2(n+2)}{l(2n+1)} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (10)$$

Equating equations (8) and (10), and solving for the unknown power n, we get:

$$n = \frac{\left(\frac{2Wl^3}{EI} + 8f_p - 5l\right) - l\sqrt{\left(3 - \frac{2Wl^2}{EI}\right)^2 + \frac{24Wlf_p}{EI}}}{4(l - f_p)} \quad \ldots\ldots\ldots (11)$$

For $f_p = 0$, i. e., for the axial load W alone the above expression reduces to $n = \frac{Wl^2}{EI} - 2$, which is the same as in equation (4) as derived for Case 1.

Case 3. **Column Subjected to an Axial Load and to a Horizontal Uniform Pressure.**—The expression for the bending moment for this condition, illustrated in Fig. 3, is:

$$M = \frac{EId^2y}{dx^2} = \frac{wlx}{2} - \frac{wx^2}{2} + Wx^n \quad \ldots\ldots\ldots\ldots (12)$$

By integration, as before, the maximum deflection at the center is found to be:

$$y = l^n = \frac{5wl^4}{24EI} + \frac{Wl^{n+2}}{EI(n+2)} \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (13)$$

which gives the same result as for Case (1), since the first term in the above expression, $\frac{5wl^4}{24EI}$, is the deflection due to the uniform horizontal pressure instead of the concentrated force, as in Case 2. The expression for n therefore becomes identical with that of Case 2, as given by equation (11), except that f_p becomes the deflection at the middle due to uniform pressure.

Case 4. **Column Subjected to an Axial Load and Any System of Horizontal Forces.**—Denoting by f the total maximum deflection due to the system of horizontal forces only, by aL its distance from the upper end of the column (as shown in Fig. 4), by x^n the total deflection at any point in the length aL, and bearing in mind that the maximum deflection for the entire system of forces will also occur at the distance aL from upper end as well as the maximum deflection due to W alone, the expression for the total maximum deflection at the above point by proceeding as before becomes:

$$y = (aL)^n = f + \frac{W(aL)^{n+2}}{n+2} \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (14)$$

Since the condition of deflection is different at each side of the point of maximum deflection in the column, the expression $y = x^n$ can only be true for the distance aL until the maximum deflection is reached. The deflection at any point in the length (1—a)L at a distance x from the lower end of column may therefore be expressed by

TABLE I.—COMPARISON OF MAXIMUM DEFLECTION VALUES OBTAINED BY THEORETICAL FORMULA WITH THOSE ASSUMED IN GORDON'S COLUMN FORMULA.

Section.	Area, A.	Axis.	Moment of inertia, I.	Radius of gyration, r.	Distance, c, in.	W, in lb., by Gordon's formula: $\frac{50{,}000A}{1+\frac{(12L)^2}{18{,}000r^2}}$	Deflection in in. by formula: $\frac{(12L)^2}{18{,}000c}$	Deflection in in. by formula: $(12\,l)^{[W(12\,l)^2\div EI]-2}$
12-in. I 31½-lb.	9.26	X-X	215.8	4.83	6	407,500	0.53	0.0053
		Y-Y	9.5	1.01	2.5	111,000	1.28	31,806,700
15-in. I 42-lb.	12.48	X-X	441.8	5.95	7.5	570,000	0.42	0.0013
		Y-Y	14.62	1.08	2.75	166,500	1.16	16,124,300
20-in. I 65-lb.	19.08	X-X	1,169.5	7.83	10.0	905,000	0.32	0.0004
		Y-Y	27.85	1.21	3.125	300,000	1.02	3,908,800

Note.—For all sections, $L = 20$ ft.; $l = \frac{L}{2} = 10$ ft.; E = modulus of elasticity = 30,000,000.

$y = (cx)^n$, where $c = \frac{a}{(1-a)}$, since for the point of maximum deflection $(aL)^n = [c(1-a)L]^n$.

The maximum deflection due to W alone may now be derived by the "principle of work" by taking it at a distance aL from the upper end and at a distance $(1-a)L$ from the lower end. Hence,

$$f_w = \frac{1}{WEI}\int_0^{aL} M^2dx + \frac{1}{WEI}\int_0^{(1-a)L} M^2dx = \left.\frac{Wx^{2n+1}}{(2n+1)EI}\right|_0^{aL} + \left.\frac{Wc^{2o}x^{2n+1}}{(2n+1)EI}\right|_0^{(1-a)L} = \frac{Wa^{2n}L^{2n+1}}{(2n+1)EI} \qquad (15)$$

Putting f in equation (14) equal to $k(aL)^n$, and solving for k, we get:

$$k = 1 - \frac{W(aL)^2}{EI(n+2)} \qquad (16)$$

Equating the two expressions for f_w from equations (14) and (15), and substituting for $(aL)^n$ its value $\frac{f}{k}$, we get the following expression for k:

$$k = \frac{f(n+2)}{aL(2n+1)} \qquad (17)$$

Equating (16) and (17), and solving for the unknown power n, we get:

$$n = \frac{\left(\frac{2Wa^4L^3}{EI} + 4f - 5a^2L\right) - a^2L\sqrt{\left(3 - \frac{2Wa^2L^2}{EI}\right)^2 + \frac{12WLf}{EI}}}{2(2a^2L - f)} \qquad (18)$$

For $a = \frac{1}{2}$ and $L = 2l$ the above expression reduces to equation (11), where f becomes f_p the deflection due to a single concentrated force or uniform pressure, or the deflection due to any system of horizontal forces producing a maximum deflection at the center.

For $f = 0$ and hence $a = \frac{1}{2}$ and $L = 2l$ the above expression reduces to that of equation (4), i. e., for Case 1, where the column is subjected to an axial load only.

Equation (18) is therefore a general expression for the unknown n, for free-end columns, while the expression for the bending moment due to the axial load W, for any system of loading, is $M = Wx^n$, where x^n is the deflection at any point in the column due to the entire system of loading.

If one or both column ends are fixed, expressions for the power n can be obtained in a similar manner and may therefore be omitted here.

General Conclusion.—A comparison of maximum deflection values determined by the expression $y = l^{(Wl^2 \div EI)-2}$, from equation (4a), with those assumed in the well known Gordon's formula for the ultimate strength in columns with free or pin ends is given in Table I.

The results in the table indicate that, for the same ultimate loads assumed, the maximum deflection values according to Gordon's formula are far in excess of those theoretically determined by equation (4a) with respect to the axis X-X, whereas with respect to the axis Y-Y equation (4a) gives ridiculously excessive values as compared with the deflections assumed in Gordon's formula for the same axis.

The first discrepancy may be generally explained by the fact that the assumption made in Gordon's formula, as well as in many others, that the deflection in a column varies only as $\frac{L^2}{c}$, or directly as the square of the length and inversely as the distance of the extreme fiber from the respective axis, is incorrect; since it does not involve the moment of inertia of the column section nor the load applied, whereas equation (4a) involves both of these quantities upon which the deflection must necessarily depend, as in the case of beams. To illustrate the above, let the 20-in. 65-lb. I-beam in Table I be loaded as a simple beam, whose ends are free, with a concentrated force at its center, first placed normally to axis X-X, then normally to axis Y-Y of its cross section; also let the concentrated loads for the two axes be the same as in the table. Using the common deflection formula for this case, $\frac{WL^3}{48EI}$, the deflection about Y-Y is found to be 14 times the deflection about X-X. However, according to Gordon's formula, with the loads applied axially as given in Table I, the deflection about Y-Y is only 3.2 times the deflection about X-X, which would seem improbable.

The second and more severe discrepancy of results with respect to axis Y-Y between equation (4a) and that assumed in Gordon's formula may, on the other hand, point out a probable incorrectness of treating the bending moment in a column due to an axial load with respect to one axis only, i. e., with respect to either X-X or Y-Y of its cross section. This may be well explained by the fact that the eccentricity of the axial load causing bending in any cross section of the column is the distance of the load from the longitudinal column-axis, which is the center of gravity of the section. It may follow from the above that the notation, I, in the expressions for both bending moment and deflection due to axial loading, as derived above, should be taken as the polar moment of inertia of the section with respect to its center of gravity, or $I = I_x + I_y$, thus eliminating the impossible deflections obtained with respect to axis Y-Y on account of the usually small value of the moment of inertia of beams about their weaker axis.

IRRIGATION PROBLEMS.*

By J. W. Beardsley, Chief Engineer, Porto Rico Irrigation Service.

1. Construction has advanced more rapidly than settlement. The securing of capable settlers is necessary to save many projects from financial failure. The human problem is greater than the technical.

2. Increasing the duty of water is likewise necessary. The irrigation engineer is responsible for decreasing canal and conduit losses, but more especially the irrigator, or farmer, is responsible for efficient methods of irrigation and the utilization of a given volume over an increased acreage. It is not unreasonable to claim that on most projects the duty of water based upon the largest financial returns can be doubled, or in other words, the

---

*Extract from a paper in "The Cornell Civil Engineer," January, 1916.

cost of construction per acre can be reduced by 50 per cent.

3. Reduction in operating and maintenance expenses is required together with a progressive improvement of the entire system. Structures of temporary materials must be replaced with permanent material. Efficient operation and maintenance methods must be followed. The manager should conserve all preventable losses of water. He should know more about the output of his plant and about the human factors involved.

4. Those failing projects, the promoter of which might have been unscrupulous or the engineer too optimistic in estimating the available quantity of beneficial water, need reorganization and to be placed on a correct technical basis and under progressive scientific management.

SUMMARY AND LATEST RESULTS OF EXPERIMENTAL WORK ON ACTIVATED SLUDGE AT MILWAUKEE, WIS.*.

By T. Chalkley Hatton, Chief Engineer, Milwaukee Sewerage Commission.

During the year just ended the Mecca for those seeking the most recent information upon the subject of sewage disposal seems to have been transferred from Atlanta to the city of Milwaukee, judging from the great number of engineers and municipal officers who have visited us from all parts of North America.

The information sought has required these visitors to ask a mass of questions pertaining to the operation of the experimental work being done at Milwaukee, and it has been the unvarying custom of those in charge to answer all as fully and fairly as was possible with the information on hand. These answers, being given orally, may or may not have been fully comprehended at all times, and, for the purpose of putting them in writing in as brief form as possible, not only to help those who have visited us, but those who have not, and are interested in this new process of sewage disposal, the author ventures to present this brief paper.

Early Experiments.—Experiments on the activated sludge process of treating sewage has, as many of you know, been carried on in the city of Milwaukee since the beginning of 1914. Their magnitude has been greater than those carried on anywhere in the world, and great care has been exercised in securing as reliable data as possible.

To this end the experiments have been conducted under the immediate direction of Mr. William R. Copeland, Chief Chemist to the Sewerage Commission, a gentleman who has spent 20 years of his life continuously upon experimental work connected with water and sewage purification. He has been ably assisted by a staff of two chemists, two bacteriologists, three engineers and several unskilled men.

The plant has been equipped with the best apparatus available to determine the volume of sewage treated, volume and rate of air applied, and the making of the chemical and bacteriological investigations. It has been run continuously night and day, always with skilled supervision on duty.

Early in March of 1914 laboratory experiments were begun by using two glass tubes 6 ft. long and 1¼ in. in diameter. At the bottom of one a filtros plate was inserted through which the air was passed and diffused. A small glass tube was placed inside of the other tube, and carried to near the bottom of the latter. Through this smaller tube the air was discharged from an orifice and diffused throughout the mixture of sludge and sewage contained in the large glass tube.

This experimental plant was erected and operated simply to secure information necessary to design a larger outside tank for trying out the process, and also to observe the difference of the effect of diffusing the air through a porous plate and open orifice.

Two very interesting points were drawn out by these early experiments. First, that with a small volume of air per minute almost any degree of nitrification required could be obtained if the air was applied a sufficient length of time. Thirty parts of nitrates in the effluent after 42 hours' aeration were common. Second, that there appeared to be little difference in the character of effluent obtained by the same volume of air applied, whether the latter was applied through the open jet or the filtros plate.

The second series of experiments were conducted in a tank (improvised from a chemical precipitation tank), 32 ft. long, 10 ft. 6 in. wide and 10 ft. deep, having a volume, when in operation, of 22,200 gal. In the bottom of this tank there are 51 filtros plates set in castings. The plates are 12 in. square and 1½ in. deep. The ratio of plate surface to tank surface is about 1 to 6.6. The coarse screened sewage is discharged directly from an orifice box (in which its volume is measured), in one end of the tank. The effluent is drawn off by means of a floating circular weir.

This tank was put in operation on May 6, 1914, and was continuously operated until Nov. 24. Numerous variations were made in the cycles, volume and rate of air, but, under normal conditions, the cycle was as follows:

Filling 1 hour, aeration 3½ hours, settling ½ hour, drawing 1 hour. As soon as filling began the air was always turned on for the purpose of blowing the precipitated sludge off of the top of the filtros plate before the full head of water, when the tank was full, made the operation more difficult; thus the average aeration period was 3 hours only.

The third line of experiments was conducted in two inspection tanks 10 ft. deep, 5 ft. wide, by 1 ft. between sides. In each of the sides glass windows were inserted to permit of observing the action of the liquid during the several operations.

The method of diffusing the air in these tanks was varied. The open jet, filtros plate and monel metal cloth were used upon the same sewage, at the same rates, at the same time, and the results determined.

These experiments were conducted from June to the middle of November and gave us some very valuable information.

The fourth line of experiments was carried out to test the process by the continuous flow method. The tank used was the same size as, and built alongside of, the tank in which the second series of experiments was conducted by the fill and draw process. It was 32 ft. long, 10 ft. deep and 10 ft. 6 in. wide. One-sixth was divided off at one end for the sedimentation chamber, and the balance was divided into a continuous channel about 3 ft. 4 in. wide and 81 ft. long, at the bottom of which 42 filtros plates were set in castings, and air delivered to the underneath side of the plates. This tank was put in operation (after securing activated sludge), the first of August, and has been in continuous operation to date, with the exception of necessary shut downs due to the break down of the main sewage pumping station.

Many series of experiments have been conducted with this tank. The volume of air has been varied from 1 to 3 cu. ft. per gallon of sewage treated. The rate from 75 to 200 cu. ft. per minute. The rate of flow from 22,000 gal. to 74,000 gal. per 24 hours, or from 14 hours to a little less than 4 hours' running through period, and a great many observations made for controlling the sludge feed and the effects upon the process by varying volume of activated sludge.

Another set of very interesting experiments has been conducted in an all glass tank, and other vessels, to determine the best method of breaking up the air into small bubbles, and its effect upon the purification, the volume of air needed for oxidation and for agitation, and the portion from which no results were obtained. The probable economy in mechanically agitating the liquor has also been studied.

The dehydrating of the sludge has been tried by pressing in a filter press, draining on sludge beds and by pressure due to a head of water up to 26 ft. deep. Many samples of the sludge have been analyzed, and some degreased and reduced to fertilizer. Much of this work has been done by chemists and engineers connected with Swift & Co., Armour & Co. and Sulzberger & Sons of Chicago, who have enthusiastically co-operated with us in much of our work.

---

*Paper before joint annual conventions of Illinois Section of American Water Works Association and Illinois Society of Engineers and Surveyors, Urbana, Ill., Jan. 27, 1916.

Having given a general description of the apparatus used and work done in obtaining the information and records at the Milwaukee experimental station the logical sequence is to present the conclusions we have reached from these experiments. In doing this the writer is not going to present a mass of figures, as these will all appear in the Second Annual Report of the Sewerage Commission, which will appear in March, it now being in the hands of the printer.

The sewage treated has been taken from the main intercepting sewer serving a population of about 275,000, to which is added the liquid wastes from the packing house district, tanneries, breweries, and other large and varied industries.

Its average characteristics for the year have been as follows: 16.3 cu. yd. of solids per million gallons settleable in 2 hours; 259 parts per million of suspended matters, varying from 150 to 600 parts, 1,109 parts of total solids; 32.9 parts of organic nitrogen, 125 parts oxygen consumed; 2.2 parts of dissolved oxygen, and 1,461,000 bacteria per cubic centimeter at 20° C. Temperatures have ranged from 44° to 70° F. The variation of flow and strength of sewage throughout the average week is approximately 82 per cent.

Air Diffusion.—We feel that the best method of diffusing air has not been determined, although there are many available. As the use of this process becomes general this problem will no doubt be satisfactorily solved by progressive means.

The open air jet reduces the loss of air pressure, but reduces its efficiency owing to the size of the air bubbles produced. This objection may be overcome by reducing the size of the orifice. We found by an orifice 1/1000 in. 1/32 in. in diameter bubbles would be produced, which is below what we term the critical size. It is problematical whether such small orifices would be kept free due to the small particles of solid matter carried along with the air.

Another objection we found to the open jet is its tendency to clog the air feed pipes with sludge drawn into the pipe when the air is shut off for any reason.

The monel metal cloth has only been tried out for about a month, and has proved quite satisfactory. Although, much more porous than the filtros plate, it produced smaller bubbles, due probably to the fact that the surface of the cloth was smooth and the air, while building the bubble, could not adhere to the surface as it does to the rough granular surface of the filtros plate.

Kisselghur was tried out. This gave the smallest bubbles of any other agent tried, but the initial frictional loss sustained in getting the air through a plate ½-in. thick was 20 lb., which made this diffuser impracticable owing to cost.

The filtros plates, if furnished of uniform porosity, have given the most satisfactory results, but they have a few characteristics which should be realized.

This material is manufactured by the General Filtration Co. of Rochester, N. Y., and was designed to filter water rather than sewage. It is made in plates 12 in. square by 1½ in. thick, and composed of quartz sand, supposed to be of a uniform coefficient according to the porosity of plate required, baked until it is quite hard and strong.

It is produced in several different grades which are classified in conformity with the volume of air which each plate will pass, when dry, per minute under a pressure due to 2 in. of water. These classes run from 0.5 cu. ft. of air to 12 cu. ft. per minute.

Table I gives the comparison of results obtained by using filtros, air jet and monel metal cloth.

It is of the greatest importance that the agent used shall diffuse the air uniformly per cubic foot of liquor, therefore great care should be taken in getting a diffuser of uniform porosity. So far this has not been possible with the filtros plate. Out of 780 plates tested by us for our new 2,000,000-gal. plant, where we specified a plate which would pass 2 cu. ft. of air per minute under a 2-in. water pressure, and allowed a 5 per cent variation either way, 35 per cent of the plates received were rejected and only 27 per cent came within the strict terms of the specifications.

TABLE I.—COMPARATIVE RESULTS WITH FILTROS PLATES, AIR JET, AND MONEL METAL CLOTH.

Diffuser.	Period, 1915.	Pressure of Mercury in pounds.	Vol. of air used in cu. ft. per gallon.	Per cent of bacteria removed.	Nitrate formed in P. P. M.	Stability of effluent in hours.
Filtros Plate,	June 1 to Aug. 12	4.3	2.06	91	3.4	78
Air Jet,	June 1 to Aug. 12	3.5	1.94	91	2.2	52
Filtros Plate,	Nov. 18 to Dec. 7	4.6	1.71	90	0.3	113
Monel Metal,	Nov. 18 to Dec. 7	3.0	1.71	80	0.2	63

The manufacturers have, since our troubles, recognized the necessity for exercising greater care, and are equipped to furnish more uniform plates, and to test them before shipment.

Tests made with the plates used showed that when wet the initial loss of pressure due to passing the air through the plate under 5 lb. pressure was ¾ lb., and for every cubic foot of air per minute per square foot of surface passing the plate there was an additional loss of ¼ lb.

There are two ways of overcoming this great frictional loss, and the factor is an important one to consider in large plants. One is by reducing the thickness of plate to, say, ½ in., and reinforcing it with wire similar to window glass reinforcement; and the other is by soaking the plate, before use, in a mixture of paraffin and benzine, blowing with air until the paraffin appears at surface of plate. This establishes fine pores through the plate, which are coated with a non-absorbent, permitting the air to pass with the least friction and the paraffin impels the water so that the plate does not become waterlogged.

We have been operating filtros plates for nine months under all sorts of conditions, and have observed no difficulty in keeping the plates from absorbing the solids in the sewage, or becoming clogged on the underneath surface. It may be possible for the pores to become filled in time with bacterial growths, which may be removed by forcing heated air through them.

It is necessary, however, to filter the air before delivering it to the plate to prevent the dust and dirt from reaching it. This is done by passing the air through a filter composed of excelsior built into the feed line.

Much space has been taken up by the writer to explain the agents used for diffusing the air, as this is a very important factor in reducing the cost of the process. The efficiency of the air varies almost directly as the size of the bubbles. We call the critical diameter ⅛ in. Below this size the efficiency increases very rapidly and the reserve is true for bubbles over this size.

There are three factors of special importance to be considered in choosing a diffuser agent. First, the smaller the air bubble produced the greater the efficiency. Second, greater density increases the frictional losses, and hence the cost. Third, the tendency to absorb and retain sludge, or to permit it to reach the underneath surface of the diffuser tends to reduce the efficiency of the diffuser, and allows sludge to precipitate on the top surface of the diffuser.

Our experiments to determine the volume of air required for oxidization and for agitation, and the volume delivered from which no useful work is secured, have not been conclusive, except to show that far more energy is imparted by the volume of air supplied than necessary for oxidization or agitation, but the air performs other useful work in the process, which cannot be performed by mechanical agitators, the exact nature of which we have not yet ascertained.

Purification can be effected by means of mechanical agitators with less air than where air agitation is used, but the time required is much greater, and the sludge is broken up into much smaller particles, is less absorbent and settles less rapidly.

From our experimnets along these lines we are of the opinion that the most economic agent for agitating the liquor is air applied in such volumes as may be determined in each case to procure the degree of purification desired, and this naturally brings about the statement following:

Functions of Activated Sludge.—Activated sludge accomplishes four principal functions: The clarification of the liquor, removal of the putrescible organic matter, reduction of bacteria and finally, if the process be continued for a sufficient period, oxidizes the ammoniacal compounds into nitrates. Therefore one of the first steps in designing a plant in which this process is to be employed is to determine the degree of purification required, following which the question arises as to efficiency, volume of air required, period of application and volume of activated sludge necessary to be kept in retention with the raw liquor.

Our problem in Milwaukee embraces the clarification of the liquor, securing an effluent stable for five days, the reduction of the suspended matters 90 per cent and 95 per cent removal of bacteria at 20° C. With our continuous flow tank we have secured this average effluent for months by using 1.75 cu. ft. of air per gallon of sewage with 4 hours' aeration, 20 per cent activated sludge and from 10 to 15 minutes' sedimentation period. Basing these results upon the operation of a 50,000,000-gal. plant, the estimated cost will be $4.38 per 1,000,000 gal., including all overhead and boiler room charges, but excluding engine room and plant attendance, and the cost of disposing of the sludge.

There appears to be no difference in the results obtained by carrying out the process either by the "fill and draw" or "continuous flow" methods considering volume of air applied per gallon, cost of aeration and volume of activated sludge required; but measured in terms of cost of construction and operation the "continuous flow" is the superior method. With a wide variation in strength of liquor and rate of flow a more uniform standard of effluent can be obtained from the "fill and draw" method because it is susceptible of better control, which is true of all "fill and draw" processes.

In order to maintain clarification and stability, and remove at least 95 per cent of the bacteria from the Milwaukee sewage we have found it necessary to carry on the nitrogen cycle far enough to develop from 3 to 5 parts of nitrates. This has not been at all difficult to maintain.

Effects of Cold Weather.—We have just passed through a very interesting period, the description of which fits in at this point. By reason of a shut-down, for two weeks, of the main sewage pumping station no sewage could be obtained for running our experimental plant. Wishing to conserve the activated sludge in our tanks we continued to aerate them quietly throughout this period without adding any fresh sewage. The nitrates decreased from 5 parts to about one-half part, when the station was started. Immediately the temperature of the atmosphere grew very cold, snow came, followed by two days of thaw, followed by several days of temperature from 5 to 15° below zero.

During this time the temperature of the sewage ranged from 55° F. to 42° F; the effluent has been uniformly clear with four days' stability, 90 per cent removal of bacteria and a reduction of nitrates from 0.7 to 0.5, there being about the same amount in the raw sewage. During this time the volume of air, rate of application and volume of liquor treated was not changed from the cycle in which it was being operated prior to the shut down.

This indicates that the low temperatures are not going to affect the process as much as we had anticipated. We believe, however, that the effect of such low temperature continuing over long periods may be easily overcome in one or two ways; either by adding more air, or a higher degree of activated sludge, or both. Thus the trouble can be overcome without excess tankage.

If more air is applied for a greater period of course the nitrates are greatly and rapidly increased. This increases the value of the sludge. Whether this increase will pay for the additional air used is a matter yet to be determined.

Table II, taken from the results obtained during a line of experiments on the "fill and draw" tank, illustrates the effect of the same rate of air applied over increasing periods.

TABLE II.—EFFECT OF CONSTANT RATE OF AIR APPLICATION OVER INCREASING PERIODS.

Purification of sewage compared with period of aeration.

Period of Aeration in hours—	0	1	2	3	4	5
No. of cubic feet of air per minute	0	160	160	160	160	160
Cu. ft. of air per gallon	0	0.67	1.32	1.98	2.64	3.31
Appearance of settled liquor	Turbid	Clear	Clear	Clear	Clear	Clear
Stability in hours	0	2	33	120+	120+	120+
Per cent bacteria removed.	0	52	81+	92+	95+	98+
Parts per Million—						
Free ammonia	22	17	15	11	7	5
Nitrite	0.08	0.00	0.95	1.75	2.20	2.50
Nitrate	0.08	0.04	0.70	2.80	5.60	8.20
Dissolved oxygen	0.00	0.30	1.90	4.30	5.90	6.70

These data clearly point to the fact that well activated sludge coagulated the colloidal matters about as completely in one hour as in five hours. In three hours it had removed 92 per cent of the bacteria and made the effluent stable for more than five days.

The most economical ratio between diffusing surface and tank surface has not been definitely determined. Our ratios run from 1 to 5.0 to 1 to 8.5. There appears to be no appreciable difference in the results obtained. We are inclined to the belief, however, that a much greater ratio would reduce the efficiency by permitting more air to escape without giving the liquor the maximum opportunity to absorb it.

While all of our experiments have been made upon tanks holding 8 to 10 ft. of liquor, our supplementary experiments indicate that more efficiency of air can be obtained in deeper tanks by reason of the longer contact period between the air and liquor, and the tendency of the air, as it escapes from the diffuser, to break up into smaller bubbles because the pressure head upon it has been increased. Local conditions might, and probably would, largely control the depth of tank.

It appears to be true that the greater pressure for which a blower is built (considering the larger units) the greater its efficiency. That is a blower which will deliver the air at 10 lb. pressure is more efficient than one which will deliver the same volume of air at 5 lb. pressure.

Volume of Air.—The purification of sewage obtained varies decidedly with the volume of air applied. Small volumes applied for five or six hours do as well as larger volumes applied for three or four hours; but the time of aeration required to obtain a like effluent does not vary directly with the volume of air applied per unit of time. For instance air applied at a rate of 2 cu. ft. per minute purifies the sewage in less time than 1 cu. ft. of air per minute, but will not accomplish an equal degree of purification in one-half the time.

Table III illustrates this point quite clearly measured in terms of nitrates developed in effluent.

TABLE III.—RELATION OF VOLUME OF AIR TO DEVELOPMENT OF NITROGEN CYCLE.

	1.5 cu. ft. of air per gallon of sewage. Rate 75 cu. ft. per minute. —Parts per million—			3.1 cu. ft. of air per gallon of sewage. Rate 150 cu. ft. per minute. —Parts per million—		
Number of hours aeration.	Free ammonia.	Nitrite.	Nitrate.	Free ammonia.	Nitrite.	Nitrate.
0	16	0.22	0.08	22	0.08	0.08
1	13	0.00	0.00	17	0.00	0.04
2	14	0.06	0.00	15	0.95	0.70
3	..	....	....	11	1.75	2.80
4	13	0.85	1.60	7	2.20	5.60
5	11	1.05	3.20	5	2.50	8.20

There is also a limit to the volume of air applied per period of application below which it is not possible to secure any significant degree of purification. If less than 1 cu. ft. of air per gallon of sewage treated be applied for a period of four hours the degree of purification of the Milwaukee sewage rapidly decreases until little or none is effected; but, if the period of application is continued long enough, this rate of air will produce any degree of purification required.

The relation between the volume of air applied and purification obtained in the continuous flow tank is well exemplified in Table IV.

TABLE IV.—RELATION BETWEEN VOLUME OF AIR AND PURIFICATION EFFECTED IN CONTINUOUS FLOW.

Average No. of—				Parts per million—			
				Nitrogen as—			
Cu. ft. of air applied per gallon.	Gallons treated per day.	Stability in hours.	Per cent bacteria removed.	Free ammonia.	Nitrate.	Organic nitrogen.	Suspended matter.
1.80	62,000	120	98	1.95	8.5	4	11
1.53	65,000	120	99	5.79	9.0	8	9
1.12	65,000	73	91	10.10	2.3	14	42

During the periods covered by Table IV the sewage required about 5 hours to pass through the tank. The table shows that air applied for 5 hours at the rate of 1.53 cu. ft. per gallon purified the sewage very well; but when applied at a rate of about 1 cu. ft., the stability fell off very materially.

In view of the fact that the air is the most important item of cost in the operation of the activated sludge process, we tried out many experiments with a view of determining the effect of decreasing the period of aeration and rate of application. These results are shown in Table V. Results were from the same sewage treated by the two methods at the same time.

TABLE V.—DECREASING PERIOD OF AERATION IN FILL AND DRAW ACTIVATED SLUDGE TANK.

Period of test 1915.	Hours of aeration.	Cu. ft. of air applied.		Per cent bacteria removed.	Stability in hours.	Parts per million.		
		Minute.	Gallon.			Free ammonia.	Nitrite.	Nitrate.
Sept. 23-Oct. 3.....	4	90	1.71	98	120+	1.8	0.14	5.2
Oct. 4-Oct. 10......	3	90	1.28	96	95	9.9	0.41	2.9
Oct. 11-Oct. 17.....	2½	90	1.07	92	69	11.0	0.05	0.7
DECREASING RATE OF APPLICATION OF AIR IN CONTINUOUS FLOW TANK.								
Sept. 23-Oct. 3.....	4	80	1.82	97.7	120+	1.95	0.08	8.5
Oct. 4-Oct. 10......	4	70	1.60	99.6	120+	5.79	0.14	9.0
Oct. 11-Oct. 17.....	4	46	1.67	88.3	61	7.90	0.02	2.0

In both parts of Table V it is evident that the efficiency of the activated sludge treatment fell off as the volume of air applied dropped below about 1.6 cu. ft. per gallon with four hours' aeration.

During these same periods other tests were made with the small fill and draw tanks to see whether equal efficiencies could be maintained by applying 1.75 cu. ft. of air per gallon with a decreasing period of aeration provided the rate at which the air was applied increased in proportion. Table VI illustrates the results.

TABLE VI.—COMPARISON OF EFFICIENCIES OBTAINED WITH DECREASING PERIODS OF AERATION COMBINED WITH INCREASING RATE OF AIR FEED.

Period of test 1915.	Hours of aeration.	Cu. ft. of air applied per—		Per cent bacteria removed.	Stability in hours.	Parts per million.		
		minute.	Gallon.			Free ammonia.	Nitrite.	Nitrate.
Sept. 23-Oct. 4.	4	1.75	1.75	92.7	120	4.86	0.36	4.9
Oct. 4-Oct. 10.	3	2.34	1.75	91.2	120	9.39	0.60	3.0
Oct. 11-Oct. 17	2½	2.80	1.75	96.7	84	11.22	0.36	1.1

Here, as in the case of the preceding tables, it is evident that by reducing the volume of air the efficiency of the process was decreased. When the period of aeration dropped to 2½ hours, although the air feed was increased proportionately, nitrates were formed in such small quantities that the settled liquors putrefied in about four days.

This last conclusion, at first glance, would seem to indicate that the only way to handle the peak flow and strength of sewage would be best done by increasing the tankage to permit of a uniform aeration period, or nearly so. We do not think this will be the best solution, however. The peak flow and strength continues at most but 8 hours out of the 24 hours. If during the 16 hours, when the flow and strength of liquor are at an average or below, and the air supplied at a uniform rate the character of the sludge and liquor in the aerating tanks will be above the average, so that when the high flow and strong sewage is mixed the condition of the mixture will be such as to provide for excess nitrification with the addition of more air.

Therefore we believe that these factors make the process extremely flexible and adaptable to the ordinary conditions under which a sewage treatment plant must be operated, and by adding more air or richer sludge the peaks will be taken care of without additional tank capacity.

Data on Unit Quantities.—Our experiments so far indicate that with 15 ft. deep rectangular tanks 15,000,000 gal. of sewage can be treated per acre of ground covered, which includes influent and effluent conduits, sedimentation and sludge tanks, and that the cost of such tanks, including influent and effluent conduits, pipe foundations and all piping, will be approximately $18,000 per 1,000,000 gals. This cost is based upon our local conditions where the tanks have to be built out into the lake and supported upon piles 40 ft. long with 4-ft. centers.

The sedimentation period required to reduce the suspended solids to 10 to 12 parts per 1,000,000 is from 10 to 25 minutes; the latter seeming to be a maximum with low temperatures.

The English practice has been to estimate the air used upon the unit of square foot of tank surface. We soon realized that this unit required two or more computations before we reached the information required, and we have therefore used the cubic-feet-of-air-per-gallon-of-sewage unit, which we find much more comprehensive.

We now come to the consideration of the sludge, and it is interesting here to describe how the percentage of activated sludge in contact with the liquor is determined.

We speak of maintaining a certain percentage of this sludge with the sewage during aeration, and in order to establish a unit which is easily determined we have fixed on that volume settling during one-half hour. It is true this is an arbitrary determination, but it is logical, nevertheless. From a great many determinations it has been found that 78 per cent of well activated sludge will settle out of the mixture in one-half hour, and that during the next one-half hour the addition is but 4 per cent. It is desirable in operating the plant to determine frequently the volume of this sludge in contact with the liquor. One hour is often too late to get the most benefit from any change demanded. This sludge, so settled out, has about 98 per cent moisture content, and it is desirable to return this sludge to the raw sewage with as little water content as practicable, because the more water the more tank area required.

To get this result it is necessary not only to let the sludge settle for at least one-half hour, but to put it under a pressure due to a head of water over it. In our new tanks we let the sludge from the sedimentation tank settle to the bottom of a 4-ft. chamber built under the tank 35 ft. deep, from whence it is pumped out after being compacted by a head due to 34 ft. of the liquor over it. Then it is further aerated in reservation sludge tanks, again settled, and pumped from the bottom of the second sludge settling tank to the raw sewage.

From our experiments we find that under a 26-ft. head of liquor the sludge will be dewatered in one-half hour from 98 per cent to 94 per cent and lose 40 per cent of its volume. If a 94 per cent rich activated sludge can be mixed with the raw sewage as it enters the aerating tanks, the size of these tanks can be materially reduced. By extra aerating the sludge to be returned to the raw sewage it is believed that the volume of air required to treat the raw sewage will be diminished. Thus the cost will be decreased because it will require only one-fifth of the volume of air to give this sludge the extra aeration (providing 20 per cent of activated sludge is being maintained in the sewage tanks) as to give the whole body of sewage treated the same air treatment.

It has been demonstrated beyond doubt that the richer the activated sludge in nitrates the quicker the purification of the sewage and less air is required.

The sludge produced is quite brown in color, appears like pieces of finely divided sponge, and settles out of the quiet liquor very rapidly; 65 per cent will settle in 10 minutes. It is readily drained on the ordinary sludge drying beds, requiring about one-half the time of well digested Imhoff sludge, but it acts quite differently. During the first hour the liquid drains through the bottom, the sludge gradually settling upon the surface seems to close the interstices of the bed and the liquid rises to the top of the sludge from which it can be titrated without disturbing the settled sludge.

With two days of dry, warm weather its moisture content will be reduced on drying beds from 98 to 82 per cent, and in two weeks the moisture will be reduced to 65 per cent.

The sludge seems to absorb the colloidal matter very rapidly. Highly colored liquor introduced into it will be decolored in a few minutes. It has no apparent odor. When well activated the sludge produced by the Milwaukee sewage contains from 14,000,000 to 18,000,000 of bacteria per cubic centimeter, from 5 to 6 per cent of fats and total nitrogen in the form of NH_3 from 4.4 to 9 per cent based upon 10 per cent moisture. At the present market the value of this sludge when degreased and reduced to fertilizer; that is, dried to 10 per cent moisture and ground, ranges from $10 to $20 per short ton.

The Milwaukee sewage produced on an average about 3,000 gal. of sludge per 1,000,000 gal. at 98 per cent moisture. On the basis of 10 per cent moisture it produces about ½ ton per 1,000,000 gal.

The cost of dewatering, degreasing and drying the sludge has not yet been definitely determined, but from a careful study of this question it is believed this cost will not exceed $6 per dry ton. Apparatus for performing this portion of the work has already been arranged for and will be installed in our new 2,000,000-gal. plant during the coming month.

General Conclusions.—As far as we have progressed with our experiments upon the treatment of sewage by the activated sludge process nothing has occurred which indicates that the process is unreliable, unworkable or unduly expensive, although we have put it through a great many different stunts. We feel, however, that there are many engineering problems yet to be solved before the ideal plant can be designed. We cannot hope to solve all of these in the first plant built, but expect this to be done progressively as other plants are built and operated.

We feel sufficient confidence in the process to have recommended it for adoption by the city of Milwaukee covering a 100,000,000-gal. plant, the designs of which are already in course of preparation.

We do not believe that this process is the panacea for all ills common to the sewage disposal problem, or that it will best fit all conditions, but we do feel sure that where a high and uniform standard effluent is required no other known process equals it either in first cost or cost of operation; and where the plant is of sufficient capacity to warrant the reduction of sludge to fertilizer the sludge problem becomes solved as never before possible.

It has been frequently stated in public print that the process is so delicate in its operation that only by the exercise of the most careful supervision can satisfactory results be secured. We believe this to be an error, as we have found no conditions arising which would lead us to such a conclusion, and if one realizes the simplicity of the process he will certainly agree with us.

Assuming the plant is properly designed and built, there are only two main factors to be considered in successfully operating it, and these can de determined by a careful and skilled workman. Proper volume of air and activated sludge are these two factors. The character of the effluent is very well determined by two things, turbidity and suspended matter. Both can be determined by observation in a test tube. Volume of activated sludge can be determined in one-half hour by the same means. The quality of the sludge can be fairly determined by its color after the observer has had some experience.

If the character of the effluent, as measured by turbidity and suspended solids, is not satisfactory, the first step is to determine the percentage of and color of sludge; if this has been reduced two valves must be opened a little wider, the air valve to the sludge aerating tank and the sludge valve controlling the sludge feed to the raw sewage.

If this fails to get the results the air valve feeding the aerating tanks is to be opened wider. Under ordinary conditions the last step would be the first because it will immediately rectify the trouble temporarily until the sludge determinations are made.

It must be remembered that there are not several operations connected with this process such as there are in the Imhoff and sprinkling filter process, which is the only other process comparable with this measured in quality of effluent produced, and therefore not many things to do to correct any irregularities in the effluent.

The author does not wish to be understood, however, as discouraging the use of skilled supervision over sewage treatment works. On the contrary, he believes such should always be provided, and owing to the operating machinery necessary about the activated sludge process it is more probable that it will insure a higher quality of supervision being provided.

COST OF AN ILLINOIS CONCRETE ROAD.

The following costs are given in "Illinois Highways" for a concrete road built in Petty Township, Lawrence County, Illinois. The concrete was laid 10 ft. wide with 2-ft. gravel shoulders. The costs given are exclusive of contractor's profits and overhead charges. The data follow:

Amount of pavement laid 5,345.0 ft., 5,938.9 sq. yd.; width of pavement 10 ft.; length of pavement constructed with transverse joints 5,345.0 ft.; spacing of transverse joints in 5,345.0 ft. of pavement average 100 ft.; length of haul for materials, average 4.0 miles; cost of cement per barrel f. o. b. siding, $1.23; cost of sand per cubic yard f. o. b. siding, $1.12; cost of stone per cubic yard f. o. b. siding, $1.12; amount of cement used per square yard of pavement, 0.287 barrels; rate of pay for labor 20c per hour; teams, 40c per hour.

COST OF LABOR AND SUPPLIES.

	Total cost.	Cost per sq. yd.
Engineering and general supervision	[1]........	[1].....
Superintendence and inspection	[1]$ 345.00	[1]$0.058
Excavation	661.54	0.112
Gravel, 1,285.5 ton at 80 ct. f. o. b. siding	1,030.40	0.174
Unloading to storage or loading sand and stone direct	60.00	0.010
Hauling stone or gravel	872.85	0.148
Sand, 707.5 ton at 80 ct. f. o. b. siding	566.00	0.095
Hauling sand	503.70	0.084
Cement, 1,704½ bbl. at $1.23 f. o. b. siding	2,096.54	0.353
Hauling cement	301.25	0.051
Incidental hauling	42.00	0.007
Hauling and placing macadam shoulders and stone drain	25.00	0.004
Shaping and rolling subgrade and side roads	321.87	0.054
Mixing and placing concrete, handling forms and joints	735.93	0.124
Covering, seasoning and cleaning concrete	82.00	0.014
Cost of culverts and bridges	340.00	0.057
Freight on equipment	32.16	0.005
Depreciation or rental on equipment	[1]........	[1].....
Insurance, printing and incidental supplies	221.72	0.037
Total cost	$8,237.96	$1.390
Cost, excluding excavation, culverts and bridges	7,236.42	1.220

[1] Indicates paid by the State Highway Department.

SEPARATE ORGANIZATION OF ENGINEERS FOR PUBLICITY WORK INADVISABLE.

To the Editors: I am of the opinion that a separate organization of engineers for publicity work would be inadvisable. Multiplication of engineering societies would tend to weaken the position of engineers in the public eye and to diminish individual professional pride.

At present about the only mark of distinction among professing engineers comparable to the official license that is required of lawyers, physicians and the like, is membership in one of the national engineering societies, and the American Society of Civil Engineers has steadfastly endeavored to maintain its high standing by admitting only such engineers as submit evidence of professional ability and experience and personal integrity, substantiated, individually by five members of the society. The desirability of membership is attested by the fact that it has nearly 8,000 members and the restless activity that has pervaded its members, even though residing remote from the society house in New York, is evinced by the organization, during the past ten years, without assistance from the parent society, of fifteen local associations of members in different parts of the country, the largest of which is that of San Francisco with upwards of 200 active members. These associations have a stimulating effect upon the social activity of their members, and apart from the reading and discussion of technical papers, are in a position to take an active interest in local affairs, and through their connection with the parent society, to bring that body into more intimate touch with the entire country. During the past ten years the growth and activity of these associations has led the Board of Direction of the society to give considerable time to considering ways and means of stimulating and fostering their growth and influence.

In view of the foregoing it appears to the writer that the problem of publicity is one that can be effectively dealt with through the existing national societies. The first essential, district organization, is already largely accomplished. The second essential, that the questions that should be discussed and acted upon be properly introduced, intelligently considered and effectively dealt with, is the real matter before us. This brings us to your second question (Eng. & Contg., Jan. 12, 1916) as to what working plan I would suggest with the implication of personal support.

I would suggest that national societies empower local associations of members to consider and act officially upon, questions of local interest pertaining to public health, safety and convenience and to the end that an action of an association may be representative of the true sentiment of the entire membership, and that the proper field of expert service be not trespassed upon, the national societies should prescribe general rules to govern the activities of local associations. Local associations may well be trusted to conserve the interests of the profession and to act within limits prescribed by the national societies. The results of the activities of every local association should be made available to the entire membership as an inspiration to similar activity in other localities, by publishing the results of deliberations in the Society proceedings; and this publicity should be augmented by publication and discussion in the technical press.

But after all we may do within our own ranks through societies and technical publications, there still remains the general public whose ear we fail to reach. It is a difficult matter, especially in the West, to get anything into the popular press concerning the engineering aspect of public questions unless the matter smack of the sensational. It would appear that suggestions in this regard might well be forthcoming from the technical press. Let it tell us how we may effectively break into the columns of the daily paper without buying space.

In conclusion, let it be remembered that this whole question of getting together for the purpose of legitimately advertising the profession and leading the public to an appreciation of the real place of the engineer in the scheme of human progress and, incidentally, the value in dollars and cents of his services, is not by any means ignored by the existing national engineering societies. It has been a live one in the American Society of Civil Engineers for years, in connection with which reference may well be had to the presidential address of Professor Swain at the annual convention at Ottawa, Ontario, in 1913, the re-printing of extracts from which at this time would not be inopportune.

Let us try to make effective use of the tools ready to hand instead of flying to others we know not of. Not a new national organization, but a new spirit among the individual members of the existing organizations is wanted. Every engineer with the good of his commonwealth and his profession at heart, should shun exclusiveness and court the society of his fellowman, where public questions are discussed and lay opinions formed. He should join the chamber of commerce, the district improvement club, the tax association, etc., and thus place himself in a position to hear and help solve, first hand, the problems of the people. Thus will he share publicity with the merchant, the banker, the lawyer and even the politician.

Very truly yours,
E. T. THURSTON, C. E.
San Francisco, Cal., Jan. 20, 1916.

LEYNER OIL FURNACE WITH PREHEATING FEATURE.

(Contributed.)

The No. 3 Leyner oil burning furnace, which is used extensively for heating drill steel, is now made with a preheating chamber which greatly increases the capacity of the furnace. This preheater is a section which fits between the body and cover of the furnace of the old design. It is, therefore, a simple matter to attach this section to an old furnace by changing a few bolts. Referring to the illustration, Fig. 1, it will be seen that the lower chamber is used for the final heating and the upper one for preheating. It is claimed that by the addition of the preheating feature, the space for heating is doubled, the heating capacity of the furnace is increased about 50 per cent and the efficiency of the furnace is increased correspondingly.

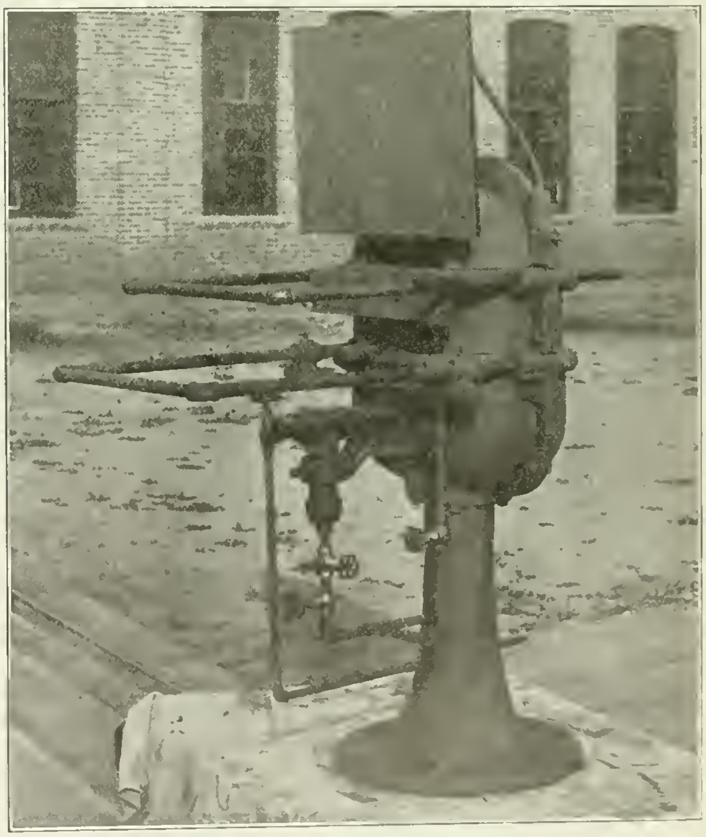


Fig 1—No. 3 Leyner Oil Burning Furnace Equipped with Preheating Chamber.

The type of burner now furnished with this furnace is suitable for either high or low pressure air. It has merely to be throttled for high pressures and when this is done, it is as efficient as burners designed especially for high pressures and eliminates the noise common to such burners.

This furnace burns petroleum or any of its oils, such as gasoline, kerosene, distillate, etc. Oil heating has many advantages. The steel cannot be injured by absorbing injurious elements such as sulphur, phosphorus or other impurities which are present in nearly all coals, nor from unequal heating as the steel is heated in a flame which imparts a uniform temperature. The steel is in full view of the operator at all times.

The floor space occupied by the No. 3 furnace is 3 by 4 feet. No foundation is required, installation being complete when air and oil supply pipes are connected.

The absence of smoke, soot, dust, ashes and cinders is a great convenience, which is particularly appreciated in underground mine installations and in plants installed in buildings.

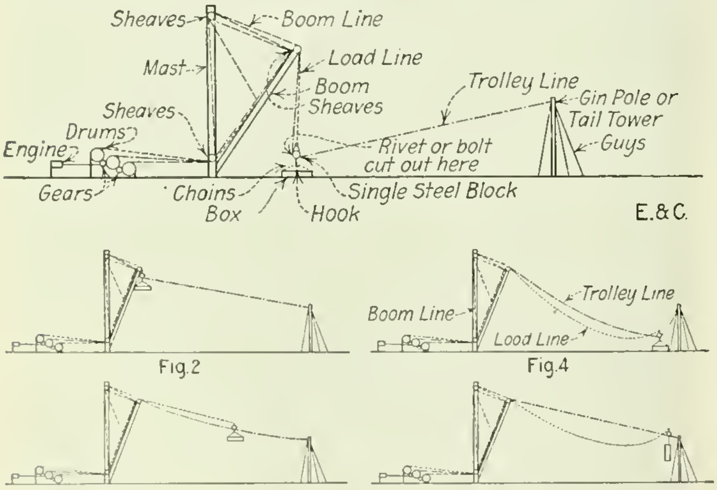
The manufacturers are the Ingersoll-Rand Company, 11 Broadway, New York.

METHOD OF DEPOSITING MATERIAL BY DERRICK BEYOND REACH OF BOOM.

By M. A. Milliff, Superintendent Sabina-Neilus Guard Lock, Texas.*

The fitting of the derrick and the mode of operation are shown by the diagrams, Figs. 1 to 5. Three lines are employed. From the back drum the load line runs through a sheave at the mast bottom, thence through a sheave at the boom end, and its end is made fast to a steel block. From the middle drum the trolley line runs through a stream at the mast bottom, thence through the boom end stream, thence through the steel block and thence to the top of the gin pole where it is made fast. From the first drum the boom line runs through a sleeve at the mast bottom, thence to another at the mast top, thence to boom end sleeve, thence back to a second sleeve at the mast top and thence it is dead ended to the middle of the boom.

If a two-drum engine is to be used, the boom line can be carried on a hand crab, as only an occasional change in the position of the boom is necessary. The block used is an ordinary single-sheave steel block with swivel hook. It is necessary to cut out the rivet or bolt in corner facing derrick, as trolley cable would rub on it during operation.



Figs. 1-5—Fitting of Derrick and Mode of Operation in Depositing Material Beyond Reach of Boom.

The material box is an open-end skip of 1-cu. yd. capacity, fitted with chains—one to each back corner and one to the middle of the front end. The front chain is fitted with a trip-hook. The ring in end of the chains is hooked in the hook in the block.

For the gin pole or tail tower, 26-ft. yellow pine piles were used, set up on a suitable foundation to prevent sinking into the ground under strain. Old hoisting cable was used for guys.

Operation.—Figure 1 shows position when picking up the loaded box. The operator hoists the load by picking up on the load line, bringing the trolley line tight as the load is raised and swinging the derrick around so that the boom will face the gin pole. The load is hoisted to the desired height and the trolley line tightened as shown in Fig 2. At this point the operator holds the trolley line tight with the foot-brake and then releases friction on the drum carrying the load line, which allows the box to trolley toward the gin pole as shown in Fig. 3. When the box is over desired dumping place the foot-brake holding the trolley line tight is released, allowing the box to drop as shown in Fig. 4. The hook on the front chain is then tripped and the box is dumped by bringing the trolley line tight, as shown in Fig. 5. The box is returned by pulling in on the load line and slacking off on the trolley line, bringing the box back into position for loading.

The derrick can be swung around by swinging gear or swinging engine and bull wheel as in other derrick work. It was found, however, that it was necessary to put an attachment on the end of the boom to prevent the trolley line from jumping out of the sheave when worked at an angle greater than 60 degrees each side of the line from the derrick to the gin pole.

Two derricks were used on this work, both being 10-ton steel guy derricks with 90-ft. masts and 75-ft. booms. One derrick was equipped with a three-drum 7¼ by 10-in. hoisting engine with swinging gear attached, and the other with a two-drum 8¼x10-in. engine with independent swinging engine. The 8¼x10-in. engine did the work more satisfactorily than the smaller engine.

The trolley line arrangement has been operated for a distance of 300 ft. with a 12-ft. drop. The load necessary to operate it depends on the condition of the hoisting engine and the ease with which the drums overhaul, but it is believed that a 2,500-lb. load will be found necessary to operate trolley on this flat slope.

In bailing slush out of a hole where five men filled the boxes with buckets and one foreman, one hoisting engineer and a laborer to dump the boxes completed the crew, 137 boxes have been moved in eight hours. In harder digging, where it was necessary to load the boxes with shovels, an average of 70 boxes in eight hours has been maintained with the following crew: One foreman; one hoisting engineer; and eight laborers.

THE FAILURE AND RIGHTING OF A MILLION-BUSHEL GRAIN ELEVATOR.

By Alexander Allaire, Western Manager The Foundation Co., Ltd., Winnipeg, Can.

II.

In our issue of Jan. 19, 1916, we described and illustrated the general design features of this reinforced concrete elevator and the manner and extent of its failure. The methods and procedure used in reconstructing the foundation of the work house and of righting this structure were also described and illustrated. This article applies to the methods and equipment used in sinking wells under the bin house and of righting it.

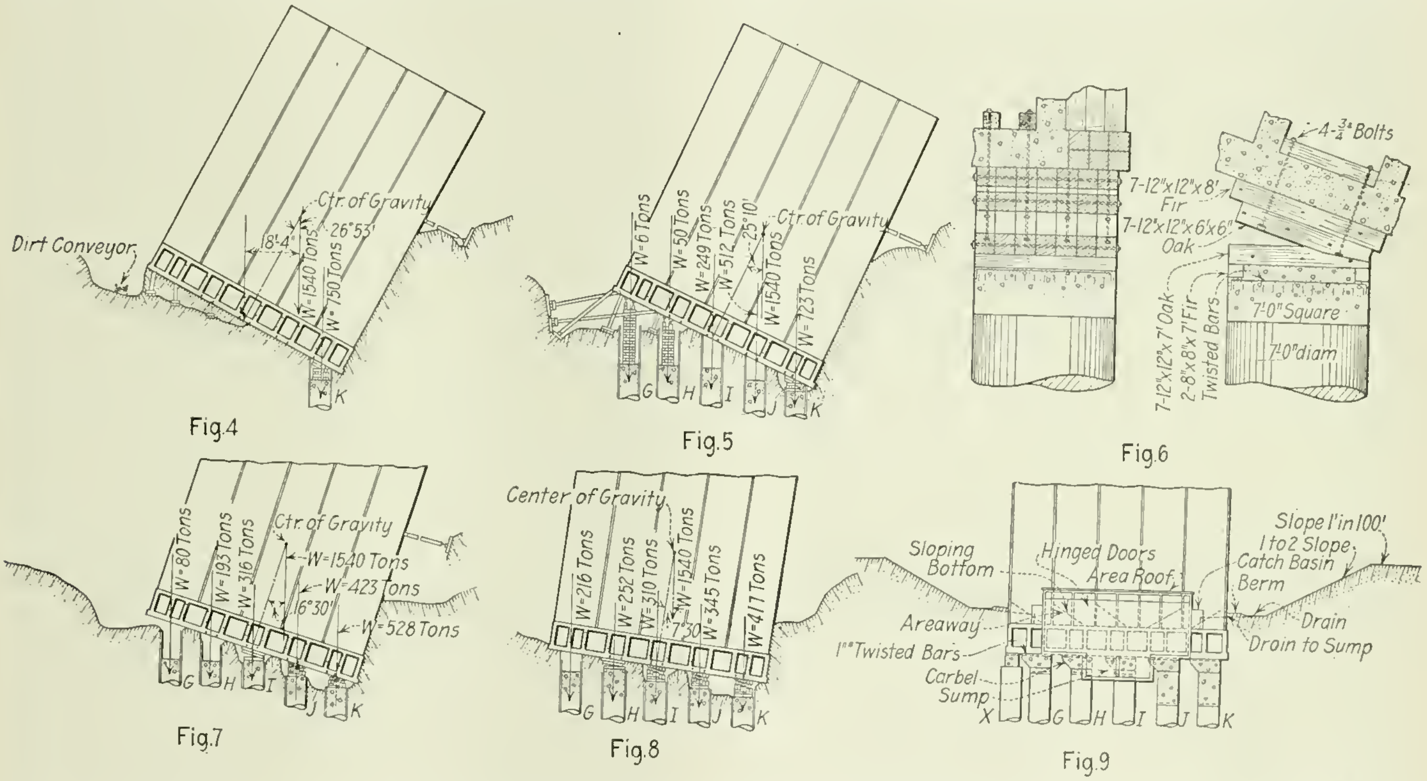
Righting of Bin House.

In the latter part of February, 1914, permission was given to The Foundation Co., Ltd., to proceed with the straightening of the bin house. When the vertical position had been reached it was planned to underpin it also by concrete piers to rock, these piers to be placed under the contact points of the tank walls in longitudinal rows. As a matter of economy it was decided not to attempt to raise the building to its former elevation, but to straighten the structure by rotating it about the low edge; this was to be accomplished by excavating under the east or high side, and lowering it to the level of the low or west side. This meant that the mat in its final position would be approximately 38 ft. below the prairie level. As this was below the ground-water line, it was proposed to waterproof it.

The bin house when empty of grain weighed 20,000 tons. Under the lower or west edge of the mat 14 piers were sunk to rock and concreted. It was the intention to block the building off these piers to form a fulcrum, about which it would rotate as the excavating was done under the high side. The clay actually under the mat was removed in two ways: first, by working from under the high edge of the mat; and secondly, through holes in the mat. The former necessitated the excavation of a trench paralleling and flush with the east edge. This was carried to a depth of about 8 ft. below the mat edge; it was approximately 10 ft. wide at this point and sloped back on the side away from the structure to the natural angle of repose of the soil. Drifts were driven from the trench toward the west, under the mat. In the trench was placed a belt conveyor which discharged upon another belt, at the north end of the building, running at right angles to the first one. This second belt emptied into a hopper from which the earth was hauled by team and spread over the prairie. The holes in the floor were in the compartments formed by the cross-walls between those of the main tunnels. The spoil passed through the holes and was handled by two conveyor belts, one in the first and the other in the third tunnel from the east. These belts discharged upon the transverse belt, previously mentioned as running along the north end. The gradual settlement of the high side was to be accomplished by weakening the core of earth left between the drifts. In driving the drifts the earth wall between them was narrowed from the bottom up, the intention being that, as the building dropped, this core would offer increasing resistance to the movement, and that this movement could be controlled by removing the earth from the sides of the cores.

---

*Condensed from article in "Professional Memoirs," November-December, 1915.



FIGS. 4-9—SKETCHES ILLUSTRATING PROCEDURE FOLLOWED IN RIGHTING STORAGE BINS OF REINFORCED CONCRETE ELEVATOR PLANT AT NORTH TRANSCONA, CANADA.

Fig. 4—Position of Storage Bins After Failure, Showing K Rows of Wells in Place. Fig. 5—Foundation Wells, Blocking and Pushers Used in Righting Storage Bins; Condition with Inclination at 25° 10'. Fig. 6—Details of Timbering and Rockers on I Row of Foundation Wells. Fig. 7—Condition with Angle of Inclination at 16° 30'. Fig. 8—Loads on Piers and Arrangement of Blocking with Inclination at 7° 30'. Fig. 9—Sketch Showing Manner of Grading Depression Around Elevator and of Corbeling Out the Pier Tops.

The 14 piers under the low side, known as the K row, were placed on the longitudinal center line of the 13 tanks, as shown by Fig. 4. They were placed under the contract walls and at the ends. Access to the sites of these wells was secured by cutting holes, 3 ft. 6 in. by 4 ft., through the mat in the compartments between the tunnels proper. The experience gained in sinking the work house wells showed that a large quantity of water would have to be handled in sinking the wells of the K row. Preparations for doing this were made by lagging down a large sump with 10x10-in. timbers at the north end of the building. This sump was carried to the depth of the low corner of the mat. It was placed inside the excavation which had been made to put in the grain leg and also the transverse belt conveyor used in connection with handling the spoil. In the sump there was erected a duplicate set of electrically-driven centrifugal pumps and steam-driven piston pumps. Each set had a capacity of 1,200 gal. per minute.

In sinking the wells of the K row, as well as the others described later, the work was performed under considerable difficulty, owing to the 27° inclination of the mat and the confined working space. Spoil from the different wells was raised by hand windlasses. The limited space and the small quantity of material to be handled would have made any mechanical arrangement more expensive.

The depth of sinking at the K wells was only 14 ft. Lagged wells of the Chicago type, 7 ft. in diameter, were used. The material was found to be very firmly compressed; in some instances the blue clay had been driven into the white stratum. The white clay, instead of being soft as it had been found at the work house, was squeezed dry and hard, so that it was usually necessary to pick before shoveling into the buckets. No water was found until the shattered limestone stratum, immediately overlying the rock, was reached.

Not only was a large quantity of water found in the K wells, which from No. 1 to No. 6 came in at the rate of 1,150 gal. per minute in each well, but, in addition, there was the danger that the level to which it would normally rise was approximately 14 ft. above the mat at the openings. This made imperative the duplicate pumping system at the sump. The insufficiency of room further aggravated the water troubles.

To do away with the multiplicity of piping of the small steam units and the almost unbearable heat from them belt-driven, electrically-operated centrifugal pumps were erected immediately above the wells. These were placed on the main tunnel floors, and independent holes for the pump suctions were cut through the mat. As it was considered inadvisable to open up too many wells at one time alternate ones only were started. As the concreting of these piers was finished, oak cribs were placed upon them to take the load of the building, as shown by Fig. 4.

As the work on the K piers was nearing completion and the majority of them had been blocked up the construction of the remaining 56 piers was commenced, it being the intention to sink these piers while the righting process was under way. These were opened up as far as possible in widely scattered positions. Although quantities of water were encountered, particularly at the north end of the building, the working conditions were somewhat better than at the K row, and the work progressed steadily. These wells were also 7 ft. in diameter; they were placed under the contract walls and tank ends, and were in all cases carried to rock. They were arranged in four rows, starting from the east, and designated as G, H. I and J.

Change in Plans.—At about this time the original plans were changed, owing to the fact that the railroad engineers had decided that they would prefer to have the tunnel floors above the ground-water level. To accomplish this the new plan contemplated allowing the bins to rotate about the K row until the angle 16° 30′ had been reached, at which time the bin house was to be pivoted about the I row of piers to an angle of 8° 30′. At this point the structure was to be again pivoted about the H row of piers into a vertical position.

As the drifts or tunnels were driven under the high side of the mat 12x12-in. posts were set up in them on mudsills of such an area that the load imposed on the soil was about 3 tons per square foot. These helped to make up for that resistance against the mat which was lost as the drifts advanced. Later, as the excavation was extended so that the sinking of the wells in the G, H, I, and J rows could be proceeded with, more posts on mudsills were added, for the same reason.

The number of posts put in also enabled the settlement of the structure to be closely regulated. This was preferable to depending only on the clay ribs, which, on occasions, had a tendency to break off in large masses. This fracturing of the clay cores also necessitated increasing the number of posts.

The posts as well as the shoring screws, mentioned later as being placed on the G and H piers, were also necessary on account of the fact that the reinforced mat, tunnel walls, and bins were not tied together vertically in any manner. Without some such precaution the mat could have broken off, or the three parts could have slid on one another.

With the bins at rest at the angle of 26° 53′, calculations showed that the loads at the pier sites were as follows:

In row—	Load, tons per pier.
G	Uplift.
H	11
I	227
J	529
K	773
Total, per transverse row	1,540

To assist in righting the bins twelve pushers were placed against the west side of the tanks. Each of these engaged a 12x12-in. waling piece placed against the side of the tanks about 45 ft. down from the top, this distance being selected so that their forces would be in a perpendicular direction to the vertical height of the tanks. The wale, in addition to resting against the 13 tanks, was also posted into the contact walls, for it was at these points that the pushers were applied. Each pusher was composed of two 12x12-in. timbers, spaced 12 in. apart by using spreaders of that dimension, and tied together by plates and bolts. Each was 60 ft. long, and each had two screws, one in each of the 12x12-in. timbers, these screws heeling against ample timber mats. The screws were operated until the mat had reached an angle of 8° 30′. The line of action of the pushers was lowered once during the righting operation so as to maintain as nearly as possible their perpendicular direction against the sides of the tanks.

Initial Righting Procedure.—The initial righting movement, namely, that of rotating about the K row, was induced by weakening the earth partition between the drifts. Practically a continuous daily movement of from 3 to 4 in. at the eastern edge was maintained. When the bin floor had reached an angle of 18° the movement was stopped for the purpose of placing the hardwood rockers at the I row of piers.

During this initial movement all the wells under the mat were successfully bottomed and concreted to the heights required for carrying on the work. As rapidly as the G and H rows were completed, crib-work was placed on each pier, with 40-ton shoring screws in contact with the mat. These screws made possible a much more positive control in lowering the mat than could have been attained by the clay rib alone. The placing of the shoring screws and posts on mudsills also permitted the removal of all the clay under the mat back to the west side of the H row of wells, approximately 23 ft. from the edge of the mat. The removal of this excavation from under the eastern edge of the mat was thus carried on more economically than if the excavation had been made through the holes in the mat. In fact, as the lowering of the mat continued, a uniform depth of the clay of approximately 8 ft. from the outer edge and 4 ft. at the line back of the H row was maintained—the belt conveyor used for the disposal of the material being also lowered from time to time as the general excavation progressed.

Shortly after starting to rotate the structure about the K row readings showed that a lateral or sliding movement to the eastward had set up. This was hard to understand, on account of the inclination of the bins to the west; also because of the compressed clay fronting the under side of the mat and to the fact that the dead load of the structure was 20,000 tons. Notwithstanding this, however, the tendency was always in evidence until the structure was pivoted on the I row of piers. To resist the movement 12x12-in. timber kicking braces, usually arranged in pairs, were used. These were of two lengths: short ones engaging the high edge of the mat and long ones reaching in under the mat to notches cut in its underside, as shown by Fig. 5. In both cases they heeled against the earth embankment on the far side of the trench, where liberal timber heels had been set up. To retard the lateral movement still more short inclined posts were set up on the K piers, their upper ends engaging notches cut in the mat. In addition, approximately 3,000 cu. yd. of earth, pressing against the bins along the west side, were removed. This total lateral movement to the west finally amounted to 3 ft. 3 in.

Use of Cribbing in Walls.—The structure was brought to rest at an angle of 18° by using cribbing placed on the J row of piers. There were two of these cribs on each pier, and they were placed in a direction transverse to the longitudinal axis of the bins. They had a total area in plan of 4x7 ft. The rear one was 2x4 ft. and it was removed later to give room for the shoring screws; the former one was used for following up with blocking as the structure rotated about the I and H rows of piers.

To form convenient working places all the tops of the piers were made 7 ft. square. In preparing the piers for the rockers (as shown in Fig. 6) 8x8-in. timbers were imbedded in the edges parallel to the longitudinal axis of the bins. The rockers consisted of two parts, the shoe and the rocker proper. The former was made by covering the top of each pier with 12x12-in. oak timbers, laid in the direction of movement and strongly bolted together. The upper surface of this shoe was concaved to a radius of 30 ft., and also in the direction of the rotation.

The rockers consisted of two courses of 12x12-in. oak timber, seven pieces in each course, directly above the timber in the shoe. These two courses were strongly bolted together and also to the mat. To make certain of an even bearing against the rough bottom of the mat, all uneven places were grouted. The lowest position, or heel, of the rocker had previously been rounded to a radius of 15 ft. Thus the area of contract of the two surfaces was 2 ft. 6 in. by 7 ft. 0 in.

Clearance was allowed between the rockers and the shoe so that contact was not made until the bins reached an angle of 16° 30′. This allowance was made in order to provide for the possibility of a slight settlement during the time required to set up the rockers. When the mat had reached this angle the center of gravity had shifted to a position 11 ft. 3 in. west of the center of the structure. At the angle of 26° 53′ it had been 18 ft. 4 in. to the west. In the new position the figured pressures on the piers (see Fig. 7) were as follows:

	Tons.
G	80
H	193
I	316
J	423
K	528

Shoring Screws and Righting Operations.—The rockers on the I row having been completed the next step consisted in preparing the K and J rows for the shoring screws. Excavation to a depth to give ample room was made from the east face of the J piers to the west face of the K piers. This excavation stepped up as the J piers were approached, to maintain a practically constant headroom and reduce the quantity of back-fill required later. Between the piers of the K row the excavation exposed the white clay, previously mentioned as having been very much compacted. Over the clay, and extending from pier to pier throughout the total length of the K row, there was laid 1ft. of concrete. On these slabs were placed oak timbers, and on the latter four 50-ton shoring screws were set up. Twelve 50-ton screws, surrounding oak cribs 4 ft. square, were placed on the K and J piers. At the time of starting the movement there were, therefore, 28 jacking units of 12 screws each and 13 of 4 screws each.

The 4-ft. square oak cribs were used to block up the mat as fast as the movement took place.

At the time of landing on the I row of piers, the mat to the east of this row had been brought in contact with the clay. From this time forward the overhang to the east of the center row was carried entirely on the clay, the shoring screws from the G and H piers having been removed to assist in jacking up at the west side. Prior to any movement of the bins, and while they were being righted, calculations were made to ascertain the weight of the structure at the different piers. These calculations were made for every 30′ of arc. From the calculations and a knowledge of the clay values it was possible to maintain such resistances to the advance of the building as would just support the mat and prevent it from fracturing as a result of overhanging the I rockers. Before pivoting on the I row of piers these studies also had governed the number and operation of the shoring screws and posts.

Further, the calculations of the weights at the different angles were applied to the conditions which would exist at the I and H rows of piers when used as fulcrums. These showed that the loading approached too closely to the safe value of the oak. The loading at the rocker points, therefore, was lessened by maintaining a calculated resistance of the clay under the east side. Extra screws under the low side were used to overcome this resistance.

The righting operations were continued, both by lessening the resistance of the clay under the overhanging portion of the mat and by jacking up the low side. Trenches were excavated under the mat from the H rows of piers eastward. These trenches extended to within about 3½ ft. of the east edge of the mat, and they averaged 4 ft. in depth, except when the mat was approaching the horizontal position, when they were allowed to fill. The bank of clay between the H and I rows was left in place. The width at the bottom of the trenches averaged about 3 ft., the sides being sloped so that each rib between two trenches had a triangular section. Continuous weakening of the clay ribs and deepening of the trenches were maintained at a rate practically equivalent to the uplifting thrust of the shoring screws. Spoil from the trenches was handled through holes in the mat.

The jacking part of the lifting operation was done by gangs made up of three men. Each gang was supplied with a 6-ft. steel bar 1⅛ in. in diameter, which, when inserted in the head of the shoring screw with three men pulling on it, was equivalent to an effort of approximately 55 tons. In the K row each gang handled eight screws, and six was the allotment for the J row. The periods of work and rest were carefully arranged, and a uniform application on the screws throughout the total length of the bins was maintained during such periods. The jacking-up process was only carried on during the day shifts. At the same time, six gangs of two men each were kept busy fleeting the screws and following up with oak blockings as progress was made. The night shift was utilized to fleet the screws, block up, and add concrete on the tops of two piers each night, and on both the J and K rows. The clay filling around the piers, to maintain the earth floor to the proper working height, was also done during the night shift.

The position of the structure was checked twice daily. In addition to levels taken at numerous points around the structure two verniers, fabricated on the work, were attached to the east walls inside of the north and south tanks of the G row. Each vernier consisted of an arc of a circle of 15 ft. radius, graduated to 5′ of arc. A wire with weighted lower end hung from the center of the circle. Prior to any movement of the bins this had been set to 26° 53′. Thus the actual angle of the structure could be ascertained quickly at all times. A 240-lb. plumb-bob was also suspended from the top edge of the west face of the bins. By these devices—in addition to the angle changes—any warping of the structure, failure of the tanks to follow the mat movement, and bending of the mat could be noted.

On September 17 the angle had been reduced to 8° 30′. Jacking was discontinued while oak rockers, similar to those used on the I piers, were placed on the H piers. As in the previous case at the I piers, allowance had been made for the creeping of the structure during the time it took to place the rockers, and they did not come to a full bearing until the angle 7° 30′ had been reached. The shoring screws were now removed from the pushers at the west side of the building and set up on the I piers. The grouping of screws during this, the final movement, was as follows: K piers, each twelve screws; J piers, each ten screws; and I piers, each eight screws. At this angle (see Fig. 8) the pier loading was as follows: G, 216 tons; H, 252 tons; I, 310 tons; J, 345 tons; and K, 417 tons. The center of gravity, in the meantime, had shifted until at this angle it was only 3 ft. 3 in. west of the center line of the structure. During this last operation it was found advisable to assist the screws on the I piers by using oak wedges, 4 ft. long, 6 in. wide, and 3 in. thick at the butt end; these were driven between the shoe and the rocker on these piers. This was made necessary on account of the tendency of the mat to sag.

An average rate of 4 in. in ten hours, measured on the center line of the K piers, was maintained throughout the jacking portion of the righting operation. The bin house was back in its proper vertical position on October 17, two days behind the estimated time. After the building had been righted the screws and blocking were removed from piers in scattered locations. In concreting up to the under side of the mat these piers were corbeled out so as to distribute the pressure, as shown by Fig. 9. The building as it stands today is practically 14 ft. below its original position, the total lift having been a trifle more than 12 ft.

To meet the new elevation of the tunnels, excavation was made in the work house, and the grain boots were lowered to receive the discharge from the tunnel belts. Also, to provide for the overhang of the bins on the east side, caused by the lateral movement, seven piers were constructed with corbeled tops to carry the outer points of the tanks.

The inclination of the bins to the north, amounting to 4 ft. in their total length, was allowed to remain. This does not affect the stability of the structure, nor the cost of handling the grain, so that any additional expense to get the structure exactly level north and south would have been unwarranted.

At the north end of the structure an areaway, 6 ft. wide and 52 ft. long, was built to a height of 15 ft. above the tank bottoms. This was roofed over with concrete, 2 ft. 6 in. above the top of the walls, the open space being left open for the ventilation of the tunnels. At the bottom of the areaway was built a sump. This extends 7 ft. below the mat, and it is 6 ft. wide and 21 ft. long. Here were installed two No. 4, motor-driven, submerged type, centrifugal pumps, having a rated capacity of 470 gal. per minute. As shown in Fig. 9 no attempt was made to back-fill around the tanks to the prairie level. Leaving the depression as shown precluded the necessity of waterproofing the tanks, which would have been necessary to protect the grain had the soil been allowed to come in contact with the thin walls. It will be noted that a berm 8 ft. wide was left around the structure. This slopes away from the bins, and forms a drain for carrying the surface water to catch-basins placed just outside of the north areaway, whence it is piped to the sump.

STANDARD ANALYSES AND TESTS OF NON-BITUMINOUS ROAD MATERIALS.*

The succeeding reprint includes the bulk of Appendix B of the 1916 report of the committee named. During the coming year a revision of this report is planned so that the present text must be regarded as a semi-final report. The extract which follows presents, first, the analyses and tests recommended for non-bituminous road materials and, second, recommended methods for performing these analyses and tests. The committee members are: W. W. Crosby, H. K. Bishop, A. W. Dean, N. P. Lewis, C. J. Tilden, G. W. Tillson, and A. H. Blanchard. The extract follows:

List of Tests.

The adoption of the following list of tests, as including all those probably of value in determining and recording the characteristics of non-bituminous highway materials, is recommended.

BROKEN STONE AND BROKEN SLAG.

- Name and origin
- Specific gravity
- Absorption of water per cubic foot
- Abrasion test, percentage of loss
- Toughness test
- Cementation test
- Crushing strength per square inch
- Mechanical analysis
- Voids, percentage of, loose and compacted

GRAVEL.

- Location
- Specific gravity
- Abrasion test, percentage of loss
- Cementation test
- Mechanical analysis
- Voids, percentage of, loose and compacted

SAND.

- Location
- Specific gravity
- Mechanical analysis
- Voids, percentage of, loose and compacted
- Tensile strength in cement briquettes, as compared with standard Ottawa sand

MIXTURES OF SAND OR OTHER FINE HIGHWAY MATERIALS WITH BROKEN STONE, BROKEN SLAG, OR GRAVEL.

- Specific gravity
- Mechanical analysis
- Voids, percentage of, loose and compacted

PAVING BRICK.

- Composition
- Name of manufacturer
- Rattler test

STONE BLOCK.

- Name and origin
- Specific gravity
- Absorption of water per cubic foot
- Abrasion test, percentage of loss
- Toughness test
- Hardness test
- Crushing strength per square inch

WOOD BLOCK.

- Character of wood
- Weight of block per cubic foot
- Soundness
- Rings per radial inch
- Quantity of preservative per cubic foot
- Absorption of water after treatment
- Character of preservative:
  - Specific gravity at 25° cent. (77° Fahr.) (See Proceedings, Am. Soc. C. E., for December, 1914, p. 3036)
  - Specific gravity at 38° cent. (100° Fahr.)
  - Solubility in benzol or chloroform
  - Water content
  - Distillation:
    - Up to 170° cent. (338° Fahr.)
    - 170° cent. (338° Fahr.) to 200° cent. (392° Fahr.)
    - 200° cent. (392° Fahr.) to 210° cent. (410° Fahr.)
    - 210° cent. (410° Fahr.) to 235° cent. (455° Fahr.)
    - 235° cent. (455° Fahr.) to 270° cent. (518° Fahr.)
    - 270° cent. (518° Fahr.) to 300° cent. (572° Fahr.)
    - 300° cent. (572° Fahr.) to 315° cent. (599° Fahr.)
    - 315° cent. (599° Fahr.) to 355° cent. (671° Fahr.)

Testing Methods.

Cement.—All properties determined in accordance with methods recommended by the Society's Special Committee on Concrete and Reinforced Concrete.[1] It is further recommended that the following methods for performing these tests be adopted as standards:

Apparent Specific Gravity of Rock.[2]—"The apparent specific gravity of rock shall be determined by the following method: First, a sample weighing between 29 and 31 g. and approximately cubical in shape shall be dried in a closed oven for 1 hour at a temperature of 110° C. (230° F.) and then cooled in a desiccator for 1 hour; second, the sample shall be rapidly weighed in air; third, trial weighings in air and in water of another sample of approximately the same size shall be made in order to determine the approximate loss in weight on immersion; fourth, after the balances shall have been set at the calculated weight, the first sample shall be weighed as quickly as practicable in distilled water having a temperature of 25° C. (77° F.); fifth, the apparent specific gravity of the sample shall be calculated by the following formula:

$$\text{Apparent specific gravity} = \frac{W}{W - W_1}$$

in which W = the weight in grams of the sample in air and W_1 = the weight in grams of the sample in water just after immersion.

"Finally, the apparent specific gravity of the rock shall be the average of three determinations, made on three different samples according to the method above described."

Apparent Specific Gravity of Sand, Stone Screenings, or Other Fine Highway Material.—The determination shall be made with a Jackson specific gravity apparatus which shall consist of a burette, with graduations reading to 0.01 in specific gravity, about 23 cm. (9 in.) long and with an inside diameter of about 0.6 cm. (0.25 in.), which shall be connected with a glass bulb approximately 13 cm. (5.5 in.) long and 4.5 cm. (1.75 in.) in diameter, the glass bulb being of such size that from a mark on the neck at the top to a mark on the burette just below the bulb, the capacity is exactly 180 c.c. (6.09 oz.); and an Erlenmeyer flask which shall contain a hollow ground-glass stopper having the neck of the same bore as the burette and a capacity of exactly 200 c.c. (6.76 oz.) up to the graduation on the neck of the stopper.

The method shall consist of: First, dry at not more than 110° cent. (230° Fahr.) to a constant weight a sample weighing about 55 grammes; second, weigh to 0.1 gramme, 50 grammes of the dry sample and pour it into the unstoppered Erlenmeyer flask; third, fill the bulb and burette with kerosene, leaving just space enough to take the temperature by introducing a thermometer through the neck; fourth, remove the thermometer and add sufficient kerosene to fill exactly to the mark on the neck, drawing off any excess with the burette; fifth, run into the flask about one-half of the kerosene in the bulb to remove air bubbles and then run in more kerosene, removing any material adhering to the neck of the flask, until the kerosene is just below the ground glass; sixth, place the hollow ground-glass stopper in position and turn it to fit tightly, and then run in kerosene exactly to the 200-c.c. (6.76-oz.) graduation on the neck, care being taken to remove all air bubbles in the flask; seventh, read the specific gravity from the graduation on the burette, and the temperature of the oil in the flask, noting the difference between the temperature of the oil in the bulb before the determination and that of the oil in the flask after the determination; eighth, make a temperature correction to the reading of the specific gravity in accordance with the table furnished by the manufacturer of the apparatus, adding the correction if the temperature of the kerosene has increased and subtracting it if the temperature of the kerosene has decreased.

Absorption of Water Per Cubic Foot of Rock.[3]—"The absorption of water per cubic foot of rock shall be determined by the following method: First, a sample weighing between 29 and 31 g. and approximately cubical in shape shall be dried in a closed oven for 1 hour at a temperature of 110° C. (230° F.) and then cooled in a desiccator for 1 hour; second, the sample shall be rapidly weighed in air; third, trial weighings in air and in water of another sample of approximately the same size shall be made in order to determine the approximate loss in weight on immersion; fourth, after the balances shall have been set at the calculated weight, the first sample shall be weighed as quickly as possible in distilled water having a temperature of 25° C. (77° F.); fifth, allow the sample to remain 48 hours in distilled water maintained as nearly as practicable at 25° C. (77° F.) at the termination of which time bring the water to exactly this temperature and weigh the sample while immersed in it; sixth, the number of pounds of water absorbed per cubic foot of the sample shall be calculated by the following formula:

---

*Extracts from report of American Society of Civil Engineers' Committee on Materials for Road Construction, Proc. Am. Soc. C. E., Vol. XLI, p. 2721.

[1] Transactions, Am. Soc. C. E., Vol. LXXVII, pp. 427-430.

[2] Proposed in 1914 by Committee D—4, "Standard Tests for Road Materials," of the Am. Soc. for Testing Materials.

[3] Proposed in 1914 by Committee D—4, "Standard Tests for Road Materials," of the Am. Soc. for Testing Materials.

Pounds of water absorbed per cubic foot

$$= \frac{W_2 - W_1}{W - W_1} \times 62.24$$

in which W = the weight in grams of sample in air, W_1 = the weight in grams of sample in water just after immersion, W_2 = the weight in grams of sample in water after 48 hours immersion, and 62.24 = the weight in pounds of a cubic foot of distilled water having a temperature of 25° C. (77° F.).

"Finally, the absorption of water per cubic foot of the rock, in pounds, shall be the average of three determinations made on three different samples according to the method above described."

Abrasion Test for Broken Stone or Broken Slag.[4]—"The machine shall consist of one or more hollow iron cylinders; closed at one end and furnished with a tightly fitting iron cover at the other; the cylinders to be 20 cm. [7.87 in.] in diameter and 34 cm. [13.38 in.] in depth, inside. These cylinders are to be mounted on a shaft at an angle of 30° with the axis of rotation of the shaft.

"At least [13.6 kg.] 30 lb. of coarsely broken stone shall be available for a test. The rock to be tested shall be broken in pieces as nearly uniform in size as possible, and as nearly 50 pieces as possible shall constitute a test sample. The total weight of rock in a test shall be within 10 grams of 5 kilograms [11.02 lb.] All test pieces shall be washed and thoroughly dried before weighing. 10,000 revolutions, at the rate of between 30 and 33 to the minute, must constitute a test. Only the percentage of material worn off which will pass through a 0.16 cm. (1-16 in.) mesh sieve shall be considered in determining the amount of wear. * * *"

Abrasion Test for Gravel.—The test for abrasion of gravel shall be made with a Deval abrasion machine. (See "Abrasion Test for Broken Stone or Broken Slag.") A charge of gravel shall consist of pieces which shall pass a screen having circular openings 5.08 cm. (2 in.) in diameter and be retained on a screen having circular openings 1.27 cm. (½ in.) in diameter. The total weight of gravel in a charge shall be within 10 grammes of 5 kg. (11.02 lb.). The gravel to compose a charge shall be washed, and dried in a closed oven for 1 hour at a temperature within 5° of 110° cent. (230° Fahr.). The charge of gravel shall be placed in one cylinder of the machine, which shall be rotated at a rate of not less than 30 nor more than 33 rev. per min. Ten thousand revolutions shall constitute a test. The percentage of material worn off which will pass through a sieve having openings of 0.16 cm. (1-16 in.) shall be considered the amount of wear of the charge of gravel. The loss by abrasion, determined as stated, shall be expressed in terms of the percentage of the total weight of the charge of gravel.

Toughness Test for Rock or Slag.[5]—"1. Test pieces may be either cylinders or cubes, 25 mm. (0.98 in.) in diameter, and 25 mm. (0.98 in.) in height, cut perpendicular to the cleavage of the rock. Cylinders are recommended as they are cheaper and more easily made.

"2. The testing machine shall consist of an anvil of 50 kg. (110.23 lb.) weight, and placed on a concrete foundation. The hammer shall be of 2 kg. (4.41 lb.) weight, and dropped upon an intervening plunger of 1 kg. (2.2 lb.) weight, which rests on the test piece. The lower or bearing surface of this plunger shall be of spherical shape having a radius of 1 cm. (0.39 in.). This plunger shall be made of hardened steel, and pressed firmly upon the test piece by suitable springs. The test piece shall be adjusted, so that the center of its upper surface is tangent to the spherical end of the plunger.

"3. The test shall consist of a 1-cm. (0.39-in.) fall of the hammer for the first blow, and an increased fall of 1 cm. (0.39 in.) for each succeeding blow until failure of the test piece occurs. The number of blows necessary to destroy the test piece is used to represent the toughness, or the centimeter-grams of energy applied may be used."

Hardness Test for Rock or Slag.—The test for hardness shall be made with a "Dorry," or similar machine, consisting of a revolving disk on which is fed, at a uniform rate, a standard quartz sand passing a 30 and retained on a 40-mesh sieve. Two cores, each 25 mm. (0.98 in.) in diameter, shall be cut from the material to be tested, and their faces ground off so as to be at right angles to the long axes of the cores. The cores shall be placed in the holders or dies and weighted so that the entire weight of each core with its holder and added weight is 1,250 grammes. Each core shall be ground in the machine on one face for 1,000 revolutions, after which it shall be reversed and ground on the other face for an equal number of revolutions. The loss of weight of each specimen shall be determined at the end of each 1,000 revolutions, and the average loss in weight shall be used for stating the hardness of the material, which latter shall be expressed by the formula: Hardness $= 20 - \frac{1}{3} W$, where W equals the average loss in grammes per 1,000 revolutions.

Cementation of Rock, Slag, and Gravel Powders.—The cementation test shall be made as follows: Of the material to be tested, 500 grammes shall be broken to pass a 1.27 cm. (½ in.) mesh sieve and then placed in a ball mill with 90 c.c. (3.04 oz.) of water and two steel shot weighing together 9 kg. (20 lb.). The mill and its charge shall be revolved for 2½ hours at a rate of 2,000 revolutions per hour. The dough thus formed shall then be removed, and 25 grammes of an average sample of it shall be placed in a metal die, 25 mm. (0.98 in.) in diameter, and subjected to a pressure of 132 kg. per sq. cm. for an instant in a hydraulic press. The cylindrical briquette resulting should measure exactly 25 mm. (0.98 in.) in height. If it does not, subsequent samples of the dough shall be taken in such quantity that the resulting briquette after compression will be exactly 25 mm. (0.98 in.) in height. Five such briquettes shall be made and allowed to dry in the air for a period of 20 hours, after which they shall be heated for 4 hours in a hot-air oven at a temperature of 93.3° cent. (200° Fahr.), and then cooled in a desiccator for 20 min. These cylinders or briquettes shall then be tested in a machine as follows:

The machine shall be arranged so that a 1-kg. (2.20-lb.) hammer is raised to a height of 1 cm. (0.39 in.), and then falls freely on a plunger transmitting the shock of the blows of the hammer through the plunger to the test piece, successive blows being struck by the hammer at a rate of 40 to 70 per min., until the test piece fails, which is indicated by the failure of the plunger or hammer to rebound. The test piece shall be placed on the anvil under the plunger without lateral support, and may be fastened in place on the anvil by a drop of shellac. The average of the number of blows on the five briquettes, required to produce failure in each case, is the result to be reported, and is the "coefficient of cementation."

Crushing Strength of Rock or Slag.—Cylinders shall be cut from a suitable block of the material to be tested, each of which cylinders shall, as nearly as practicable, be 5 cm. (2 in.) in diameter and 10 cm. (4 in.) in length. After cutting, the dimensions of each cylinder shall be accurately measured and recorded. Each cylinder shall then be subjected to compression, and the ultimate stress at which its failure occurs shall be noted. This stress divided by the average area in cross-section of the cylinder in square inches shall be reported. It is desirable that the test of the material shall be made on at least three such cylinders separately, and the average of the three or more specimens shall be taken as the average resistance to crushing of the material. In making the test, the cylinder shall be fixed in the testing machine so as to be unsupported on its sides and rest squarely on its ends, and the compressive stress shall be applied cumulatively. The ends of the cylinder shall be at right angles to its long axis, and the blocks or pieces of the machine in contact with the ends of the cylinder and through which the pressure is transmitted shall have such position and freedom of movement in the machine as will insure the application of the stress directly along or parallel to the long axis of the cylinder.

---

[4] Method adopted by the Am. Soc. for Testing Materials, August 15, 1908.

[5] Method adopted by the Am. Soc. for Testing Materials, August 15, 1908.

Mechanical Analysis of Broken Stone, Broken Slag, or Gravel.[6]—The method shall consist of, first, drying at not more than 110° cent. (230° Fahr.) to a constant weight a sample weighing in pounds six times the diameter in inches of the largest holes required; second, passing the sample through such of the following sized screens having circular openings as are required or called for by the specification, screens to be used in the order named: 8.89 cm. (3½ in.), 7.62 cm. (3 in.), 6.35 cm. (2½ in.), 5.08 cm. (2 in.), 3.81 cm. (1½ in.), 3.18 cm. (1¼ in.), 2.54 cm. (1 in.), 1.90 cm. (¾ in.), 1.27 cm. (½ in.), and 0.64 cm. (¼ in.); third, determining the percentage by weight retained on each screen; fourth, recording the mechanical analysis in the following manner:

Percentage passing 0.64-cm. (¼-in.) screen.................... =
Percentage passing 1.27-cm. (½-in.) screen and retained on 0.64-cm. (¼-in.) screen.................................. =
Percentage passing 1.90-cm. (¾-in.) screen and retained on 1.27-cm. (½-in.) screen.................................. =
Percentage passing 2.54-cm. (1-in.) screen and retained on 1.90-cm. (¾-in.) screen.................................. =
.... =
100.00

Mechanical Analysis of Sand or Other Fine Highway Material.—The method shall consist of: First, drying at not more than 110° cent. (230° Fahr.) to a constant weight a sample weighing 100 grammes; second, passing the sample through each of the following mesh sieves, the sieves to be used in the order named:

Meshes per linear inch (2.54 cm.)	Diameter of wire	
	Inches.	Millimeters.
10	0.027	0.6858
20	0.0165	0.4191
30	0.01375	0.34925
40	0.01025	0.26035
50	0.009	0.22865
80	0.00575	0.1460
100	0.0045	0.1143
200	0.00235	0.05969

third, determining the percentage by weight retained on each sieve, the sifting being continued on each sieve until less than 1 per cent of the weight retained on each sieve shall pass through the sieve during the last minute of sifting; fourth, recording the mechanical analysis in the following manner:

Percentage passing 200-mesh sieve........................... =
Percentage passing 100-mesh sieve and retained on 200-mesh sieve .... =
Percentage passing 80-mesh sieve and retained on 100-mesh sieve .... =
Percentage passing 50-mesh sieve and retained on 80-mesh sieve .... =
.... =
100.00

Mechanical Analysis of Mixtures of Sand or Other Fine Highway Material with Broken Stone, Broken Slag, or Gravel.—The method shall consist of: First, drying at not more than 110° cent. (230° Fahr.) to a constant weight, a sample weighing in pounds six times the diameter in inches of the largest holes required; second, separating the sample by the use of a 10-mesh sieve (American Society for Testing Materials standard sieve); third, examining the portion retained on the 10-mesh sieve in accordance with the method for making a "Mechanical Analysis of Broken Stone, Broken Slag, or Gravel"; fourth, examining the portion passing the 10-mesh sieve in accordance with the method for making a "Mechanical Analysis of Sand or Other Fine Highway Material"; fifth, recording the mechanical analysis in the following manner:

Percentage passing 200-mesh sieve........................... =
Percentage passing 100-mesh sieve and retained on 200-mesh sieve .... =
Percentage passing 80-mesh sieve and retained on 100-mesh sieve .... =
.... =
Percentage passing 10-mesh sieve and retained on 20-mesh sieve .... =
Percentage passing 0.64-cm. (¼-in.) screen and retained on 10-mesh sieve .... =
Percentage passing 1.27-cm. (½-in.) screen and retained on 0.64-cm. (¼-in.) screen.................................. =
Percentage passing 1.90-cm. (¾-in.) screen and retained on 1.27-cm. (½-in.) screen.................................. =
.... =
100.00

Voids in Mineral Aggregates.[7]—"The voids in mineral aggregates shall be determined by the Cone Specific Gravity Method. In the method of making the determination of voids, as hereinafter described, there shall be used a truncated cone made of No. 18 B. & S.-gage galvanized steel with caulked seams, and having the following dimensions: over-all diameter of bottom, 25.4 cm. (10 in.); over-all height, 25.4 cm. (10 in.); inside diameter of opening, 7.6 cm. (3 in.). The test shall be made in the following manner: First, thoroughly mix the aggregate by rolling on paper; second, fill the cone with aggregates avoiding segregation; third, compact aggregate in cone by oscillation on edge of cone resting on wooden floor, wooden box, or block of wood, and use cotton waste pressed against surface of aggregate to prevent segregation during oscillation; fourth, continue to add aggregate and compact until the cone is full of thoroughly compacted aggregate, which process will require from 300 to 500 oscillations; fifth, weigh cone with aggregate; sixth, weigh cone empty; seventh, weigh cone full of clean water; eighth, determine the specific gravity of aggregate; ninth, the percentage of voids in the aggregate shall be calculated by the following formula:

$$\text{Percentage of voids} = \left(1 - \frac{C - A}{(B - A)\,D} \quad 100\right)$$

in which A = the weight in grams of the cone; B = the weight in grams of the cone filled with water; C = the weight in grams of the cone filled with compacted aggregate; D = the specific gravity of the aggregate."

COSTS OF DRAG LINE SCRAPER DITCH EXCAVATION.

By D. L. Yarnell, Drainage Engineer, U. S. Department of Agriculture.[*]

A drag-line excavator of the rotary type, having a 2-yard scraper bucket and a 60-ft. boom, was used in the construction of drainage ditches in southern Texas. It was built mostly of wood and moved on rollers. Power was derived from an 80-hp. internal-combustion engine, burning oil. The cost of the excavator, ready to operate, was $12,000. It was operated about 10 months in two daily shifts of 10 hours each, a shift consisting of 10 men. The actual working time was not recorded. The ditch ranged from 4 to 22 ft. in bottom width, from 3 to 12 ft. in depth, and had 1 to 1 side slopes. The soil varied from a stiff, heavy clay to a fine sand. The excavation amounted to 230,000 cubic yards; the cost was as follows:

Operating expenses	$22,313.36
Miscellaneous expenses	374.70
Interest and depreciation	4,100.00
Total	$26,788.06

Cost per cubic yard, $0.1164.

On another drainage project in southern Texas, a 2-yard rotary excavator was used. The machine was of steel throughout, had a 60-ft. boom, and was mounted on caterpillar traction. The crew consisted of a foreman, operator, engineman, oiler, and two laborers. The machine was operated by a 110-hp. internal-combustion engine, with oil as fuel. The total cost of the machine was about $17,500. The cost of erection was $509. During the four months of operation two 10-hour shifts were run. The ditches ranged from 4 to 22 ft. in bottom width and from 3 to 12 ft. in depth, with 1 to 1 side slopes and 8-ft. berms. The material excavated was a stiff, heavy clay. The excavation amounted to 91,400 cu. yd.; the cost was as follows:

---

[6] Adapted from method proposed in 1914 by Committee D—4, "Standard Tests for Road Materials," of the Am. Soc. for Testing Materials.

[7] Proposed in 1915 by Committee D—4, "Standard Tests for Road Materials," of the Am. Soc. for Testing Materials.

[*] Extract from Bulletin No. 300, Office of Public Roads and Rural Engineering, on "Excavating Machinery Used in Land Drainage."

Operating expenses	$ 8,873.82
Miscellaneous	371.00
Interest and depreciation	2,391.00
Total	$11,635.82

Cost per cubic yard, $0.1273.

In the same general locality as the last example a 1½-yard rotary drag-line excavator, operated by a 50-hp. internal-combustion engine and mounted on caterpillar traction, was used in the construction of some ditches in soil ranging from stiff, heavy clay to fine sand. The ditches were of the same dimensions as in the foregoing example. The machine was rebuilt from an old dipper dredge at a cost of about $1,200. It was operated in two daily shifts of 10 hours each. The crew for each shift consisted of from five to six men. During the five months of operation the machine moved 59,014 cu. yd. at an expense, exclusive of interest and depreciation, of $8,921, or $0.1512 per cubic yard.

A rotary drag-line excavator with a 2¼-yard bucket and 65-ft. boom, mounted on skids and rollers, was used in the excavation of 222,500 cu. yd. in South Dakota. The power was obtained from a 50-hp. internal-combustion engine, using gasoline. The cost of the machine, complete, was $10,500. The total time of construction was 148 working days, or approximately six months, of which 23 days were occupied in making repairs. Two shifts of 11 hours each were run. The soil was a loam underlain by clay. The crew and rates per month were as follows: One superintendent, $125; 2 cranemen, at $100; 4 trackmen, at $50; 1 teamster, $45; 1 cook, $40. The operating expenses were as follows:

Gasoline, 15,444 gallons, at $0.124	$ 1,915.05
Labor	3,060.00
Subsistence	561.81
Cables	978.87
Repairs and renewals	845.93
Miscellaneous	2,078.72
Interest and depreciation	2,152.50
Total	$11,592.88

Cost per cubic yard, $0.0521.

The following costs were secured on the operation of a rotary drag-line excavator with an 85-ft. boom, 2-yard bucket, and a 50-hp. engine. The work was done on the New York State Barge Canal. The machine weighed 147 tons and cost $10,000. It excavated earth 90 ft. from center on one side and deposited it 100-ft. from center on the other. It dug a channel 25 ft. deep and deposited the material on waste bank 15 to 25 ft. high. The material was a stiff clay, with few stumps or bowlders. The following is a condensed cost record for five months' work:

Month.	Total expense for month.	Yards excavated during month.	Average cost per yard.
April	$1,088.21	5,205	$0.209
May	1,041.53	18,365	.0568
June	1,152.04	25,333	.0455
July	1,317.61	33,055	.0399
August	1,525.36	47,363	.0324

Average cost per yard for 5 months, including all charges, $0.0474.

In May, items of cost were as follows:

Engineer, at $90 per month	$ 90.00
Engineer, at $95 per month	84.04
Fireman, pumpmen, watchmen, etc., at $1.75 per day	363.00
Coal, at $3 per ton	147.00
Repairs, including labor and material	15.82
Interest and depreciation	341.67
Total	$1,041.53

SOME PRACTICAL POINTERS ON BUYING FOR A CITY.*

By Fowler S. Smith, City Purchasing Agent, Dayton, Ohio.

Radical Changes in Science of Buying.—Before entering into a discussion on buying for a city, I wish to call attention to a few of the changes which have taken place in the methods and general science of buying within the last few years. I say science advisedly, for that it is a science, and a very important one, is now generally conceded.

For years we have all heard a great deal about scientific salesmanship, but it is only recently that the poor buyer has been reckoned as of equal or greater importance in a business organization.

When I first entered the game 13 years ago as a buyer for a large manufacturing firm, we worked out and put into force a new system for handling the work which was in many ways very similar to that in general use today. And we did good work as far as we went, but our efforts were general. We bought steel and pig-iron of standard grades and never thought of inquiring into the chemical or physical composition of the material we ordered. We had no testing laboratory and did not feel the need of one. In fact, the only firms which maintained such a luxury were those which had such a large percentage of profit in their product that they could afford any innovation.

At that time the salesmen who called on us were of the old type—good mixers, who made friends with the buyer, tried to buy drinks for him and had very little in the way of real knowledge of the lines they were selling. Of course they were not all of this type, but any others were the exception rather than the rule.

Radical changes have taken place in all phases of the work since that time. Instead of the old type of salesman we meet the young technical man who goes from his college theories to a year or so of shop practice and a salesman's school, and then onto the road. He knows his business thoroughly and knows human nature. He has no time to waste and must be a live wire, or somebody takes his place.

A modern plant either maintains its own laboratory or gives its business regularly to some general testing laboratory or firm. Specifications are carefully worked out for the material that enters into the construction of every modern machine, and all material delivered is required to pass a rigid inspection. A large part of the steel, pig-iron and other raw material furnished to a factory at the present time is purchased on absolute chemical and physical analyses.

These changes have brought about an equally radical change in the character of the successful purchasing agent. The old good mixer has gone and his place has been taken by the man who does not merely work by the clock, but is thinking of his work 24 hours a day and who, by experience and study, has equipped himself as far as possible to meet the scientific salesman on his own ground.

A modern buyer can never tell when he is going to find something new and valuable—a circular in the mail or the chance word of a salesman may result in the saving of thousands of dollars. When I was still in the manufacturing end of the game, I noticed one day in passing through a factory in an entirely different line from ours, a piece coming from a punch press which gave me a suggestion for making one of our parts and the change as worked out by our engineers has meant a saving of thousands of dollars a year since then.

The changes in purchasing methods have, of course, all been brought about by the keen competition in modern business, where every penny counts, and the wise business man has come to realize that the dollar saved in the cost of material and supplies is just as big as the dollar made on the selling end.

The great progress made in a few years in general buying has been no greater, nor as great, as the progress that can be made in buying for a city. Now that we have started the possibilities of the work are wonderful and the progress will be more rapid, because we will be able to adopt, off-hand, the latest ideas from the business world, but we have still a long way to go, and a lot of hard work to do.

Peculiarities of City Purchasing.—When I first took up the city end of the work, I had an idea that it could be handled in practically the same way as in a big business, and in most ways it can be; but there are several points of difference which are very vital. To begin with, the diversity of the lines to be purchased is almost unbelievable—much greater than would be required in any one business. Consider for a moment the ramifications of the work of a thriving, modern city government. There are the Fire and Police Departments, Service Department with Sewers, Streets, Bridges, Garbage and Ashes, Water Works, Motor Vehicles, the Welfare Department with the Health, Laboratory, Recreation, Parks, Playgrounds, Prisons, Hospitals, Greenhouses, and besides these the special printing, office supplies and equipment for all departments. In view of this diversity of interests one can readily understand why a city purchasing agent has to be on the job every minute trying to keep everybody happy. It is not as though he could center his thoughts for an hour at a time on different subjects; one minute it is an automobile repair job, the next material for streets, then food supplies or women's stockings for the workhouse or perhaps marbles, jackstones or baseballs for the playgrounds; it is never the same and never lets up.

---

*Paper read before 1915 annual convention of City Managers' Association.

The next great handicap to a city buyer is the "pitiless publicity" in which he has to work. I have not yet gotten used to having a salesman who has lost out on an order come to me and demand, as his right, to see the prices and details of the entire transaction. He would not dare ask such information in any business house, and yet it has occurred many times in my office.

Besides this, we have the old custom of the public opening and reading of bids. What possible chance is there of breaking the many combines to uphold prices if every detail of a quotation must be read out to every other man in the ring? This merely encourages combination, whereas if prices could be made and contracts closed so that the details could be known only to the two parties concerned, there is practically no combine that could not be broken. Another source of publicity, the newspaper man, is not so hard to handle; I have always found them fair and willing to omit publishing any details which might mean dollars and cents to the city.

There is, I suppose, no remedy for this difficulty until the people have been given efficient government and honest officials for a long enough time for them to learn to trust them.

System for Handling Orders.—Of course one of the first things necessary after the establishment of our Division was to work out and put into force a system for handling orders, which would comply with the provisions of the charter and safeguard the city at every point, and at the same time be rapid and simple in operation, free from any old-fashioned red tape and easy to keep up with a small clerical force.

Our city charter provides that there must be full and open competition on all purchases. That no order shall be issued unless there are sufficient available funds to cover the purchase. That a sufficient sum shall be set aside and held ready to pay the bill when rendered, and that the City Manager shall approve every order. Besides fully covering all of these points our system provides a requisition in duplicate signed by division and department heads, and an inquiry for prices to vendors in such form that specifications and details are identical to all even as to cash discount and freight or delivery charges; a simple filing system, so that all details on outstanding inquiries and orders are quickly accessible; a copy of the purchase order to the successful vendor, a copy for the Purchasing Agent's files, one each to the City Accountant, the requisitioner, and the inspector, all with spaces to record date of delivery, amount received, date of payment, etc.

In a general way this is our system. The same results could be attained in a different way and perhaps a better way, but every man or set of men has his or its own ideas about the details of a system like this, and they are really not essential. We obtain the results required and do it promptly and accurately. We have received and handled since Jan. 1 (practically 10 months) 5,000 requisitions; these have resulted in 5,800 orders, and we are able to keep up the work in the Division with a force of two men besides myself. We have a card mailing list that while not complete is gradually becoming so, and a file of over 600 catalogs and circulars, indexed and cross indexed, and other necessary records and files to make it possible to do efficient work.

I wish to say here that the success of our system is due largely to our budget and to our accounting system. The buying and accounting divisions are so closely linked together that the efficiency of each is dependent on the other. The speed with which an order can be sent to the vendor depends largely upon the smooth and rapid handling of the undertaking of the account and recording of the order, and also upon the ability of the purchasing agent to obtain quickly the exact balance available in any fund.

Any one going from general buying into city buying in a city where the buying has been done under the old methods will find many petty prejudices to be overcome. Many merchants will have an idea that city business is not worth while, because of the formality and red tape in bidding and the slowness in sending remittances. There are others who feel that because they are taxpayers they must be taken care of. Another handicap is the lack of discipline which will be found, and this is almost certain to result in a lack of co-operation between departments. Under our old form of government it was a good deal of a scramble to see who could get the largest portion of the funds available and it was the welfare of the department rather than of the city at large which received first consideration. This resulted, in my division, in a certain amount of feeling that other departments were not receiving the special attention which their importance warranted. This condition was only temporary, however, and soon disappeared after we had been shaken into a real organization. There are many other petty annoyances of the same kind. These cannot be dodged and simply must be borne, for they are sure to be found in any city.

Watching the Markets.—One place where a city buyer can make a big showing is by watching the markets closely on all lines and buying as nearly as possible at the low point. Very little attention as a rule has been paid in city work to this phase of buying in the past and yet it is one of the most important things to be done. We purchased cast iron water pipe at an exceptionally low price by going into the market at the right time, when the iron market was at its lowest point and the pipe foundries wild for business to allow them to keep running. We waited three months after we knew that we would need the pipe until we judged conditions were right. After the purchase was made the market advanced several dollars a ton within two months and as we used 6,300 tons, the saving on this one item was sufficient to pay the expenses of our entire division for more than four years.

We contracted for a year's supply of gasoline on Aug. 1 at 9 ct. per gallon, the lowest point in the market here. The advance to date has been 4 or 5 ct. a gallon, with a good prospect of a further advance. As we will use 75,000 gal., we are already $3,000 ahead. Next spring we expect to build three bridges which will require approximately 800 tons of reinforcing steel. Instead of waiting to buy when we have completed plans and placed contracts, or letting the contractor furnish it at a high price, we purchased it Oct. 1 and at today's market for the same material we are $2,400 ahead, and with conditions as they are existing at present in the steel trade, we will be $4,000 ahead by the time we need delivery.

These are only a few instances of the possibilities. They come up every day and the buyer must catch them.

There are certain lines that are exclusively municipal in character and which involve the expenditure of a great amount of money. I refer particularly to fire hose, fire apparatus, etc., and it is in handling these items that a city buyer must be especially careful.

The prices and selling methods have been worked out to fit conditions as they unfortunately still exist in many cities. Political and personal influence and still more questionable tactics are used in the effort to land a big order, and the purchasing agent's biggest work before asking for bids consists in drawing up specifications which are fair to the bidder and protect the city's interest, and in other ways convincing the bidders that the old methods don't go. A large percentage is usually allowed on the prices of these items to cover selling expense. As no selling expense is possible under our present methods, I always try to have the prices cut this amount and have several times succeeded in saving up to 25 per cent of the old price. You must remember that the firms selling goods under the old methods were not alone responsible for conditions as they existed, and I firmly believe that 99 per cent of them will welcome a change to straight, clean-cut business dealing.

One of our most radical departures from the usual methods in city buying was on a purchase this year of $50,000 worth of motor fire apparatus. The bids as first received were too high for the available funds; rather than refuse all bids, readvertise and probably reach the same result, we gave all bidders the same opportunity to lower their bids, having the reduction based on our placing the entire order with one firm. We felt fully justified in doing this from the fact that all bidders were given the same opportunity, that it was obviously to the advantage of the city to buy only one type of motor and thus greatly simplify the handling of the apparatus in the department and reduce the expense of making repairs in the city garage. By taking this stand we saved just 20 per cent of the cost and were able to buy some extra apparatus.

We do not advertise anything but the largest purchases. We are not required to do it by law and it certainly does no good. The small legal advertisement is not seen by 20 people in a daily paper and the only way really to reach the people you want is to mail them the inquiry and specifications. Neither do we require a certified check or bond with bids. All contracts of course are secured by bond, but I have found that a great deal of the dissatisfaction among merchants and dealers with city business lies in the necessity of depositing a certified check. I cannot see where it is any protection to the city and I have received more and better bids since we discontinued the practice.

Working Out Standard Specifications.—The working out of standard specifications on all purchases is one of the hardest tasks confronting a buyer. It is not a thing which can be done in a hurry. What will do in one city will not necessarily do in another, owing to market conditions and local problems. I have spent a great deal of time and study on the question in the last two years and many of the specifications put out have been faulty and have had to be altered, but we have made a great deal of progress, especially on the larger items, such as fire hose, coal, etc.

On fire hose we combined the strongest points in several sets of specifications of other cities and those of the Board of Fire Underwriters and added several tests and provisions which we have found by experience are of value. We have just received our last purchase, for which we paid approximately 45 cts. per foot and from laboratory tests and analyses I believe it is as good or better than the hose we formerly bought at 85 ct. and $1 per foot.

On coal, of which we use about 10,000 tons per year, we have been very successful in buying on a B.T.U. basis. Not only the coal used in our two power plants, the water works pumping station and the reduction plant, but also that in stoves and furnaces in the various departments. We contract for the coal of various grades, in carloads, f.o.b. cars, Dayton, and make a separate contract to cover the hauling to various points.

Where formerly coal was purchased from retailers for furnace and stove purposes at $4.75 and $5 per ton, with no guarantee as to quality, we now buy in carload lots and deliver to same points a much better coal, fully guaranteed as to quality, at a price of $2.46 to $2.63 per ton, depending upon point of delivery and hauling charge. Every car of coal is sampled as received; the sample is analyzed and the shipment is paid for on the basis of this analysis.

On the last 25 cars delivered we have paid a premium on 22 cars and deducted a penalty on 3 and the cost of sampling and analysis is 2 ct. per ton. In the water works pumping station alone, where we pumped in former times 275 to 290 gal. of water per pound of coal, we are now pumping 375 to 390 gal. per pound. This is a saving of over 30 per cent, due to a certain extent, at least, to the quality of coal burned.

Our coal specifications are drawn so as to be attractive to the larger operator and jobber and I received 28 bids in July from all over the country. I am very proud to be able to say that these specifications have been adopted as standard by five prominent manufacturers in Dayton and nearby cities.

To those who are familiar with this method of buying coal, or rather of buying heat, I will only say that the average analysis of 25 cars received since July 1 when shipments on our present contract began, has been over 14,200 B.T.U., and the ash about 5 per cent.

There is one item of supplies, of which I believe a municipality uses really a larger amount than any other business, and that is printed forms, and from my experience here there was less attempt at good buying there, before we took hold, than on any other one item. There was no effort made to standardize either the size or style of the forms in use. Every man seemed to use his own fancy and placed orders with his own friends at any price. A certain form that was purchased in October, 1913, under old methods at $13.75 per 1,000 was purchased again by us in January, 1914, on the same grade of paper and same class of work for $7 per 1,000. This is only one example. We have in use now, in the various departments, over 500 forms. The necessity or advisability of every form is passed on by several persons, so that there will be no duplication in work. I have a special specification sheet and a record card for each form giving exact specifications as to weight and grade of paper, size, etc. One copy of this sheet goes to the printer, one copy to the inspector and one copy is a record in my office. I receive from four to ten bids on the printing from both union and non-union printers and place the order with the lowest bidder.

We have made all forms of standard sizes to cut out of standard sizes of paper without waste, and we use only about three grades of paper. It has been wonderful the results we have attained on this one item, saving approximately $4,000 last year. Under old methods, each office purchased its own letter-heads in small quantities; every man had a different idea of artistic merit, but they all paid from $12 to $20 per 1,000. By buying in January each year a full year's stock for all departments of a good lithographed letter-head, on good paper—in fact, a much better piece of work than any of the others—we bought them for $2.70 per 1,000.

City Storehouse.—One of the very important changes we have made has been the establishing of a city storehouse. There are in all cities any number of articles which are used by several departments. Usually the quantity used by any one department is not enough to get the lowest price, but by combining the purchases each one has the advantage of the other's usage. We have a stores fund from which we purchase such items as we can move quickly and then sell direct to departments, turning the money back into the stores fund.

The percentages saved on items handled in this way run from 40 to 80, and the total amount saved in a year will pay the cost of the storeroom many times over. Besides this, we can give quicker service than if we had to go outside and buy each item. Just a few examples of the large savings in this way are carbon paper reduced from $3.50 to 65 ct. per box, typewriter ribbons 75 ct. each to 25 ct. each, typewriter paper from $1.25 a box to 54 ct. per box, rubber bands from $4 per pound to $1.35 per pound, paper clips from $1 to 25 ct. per 1,000.

This stock room has a complete system and takes care of a great many of the little orders which would otherwise be very hard and slow to handle. We also carry cement, hay, oats and other more important articles, buying when the market is advantageous and holding in stores until required.

We have done some rather radical things, some of them, perhaps, too radical, but at least in the direction of increased efficiency. We have by no means reached the self-satisfied stage, for there is a great deal yet to be done and we hope in another year to have still greater progress to report.

In closing, I will say that after two years of city work, with many trials and tribulations behind me, I have no regrets. The field is new and broad, the work is fascinating, and a man in my work cannot help but learn many things that have nothing to do with buying. For, next to the City Manager, there is no man in a city organization who comes in as close contact with, and becomes as familiar with the inside working of every department, division and bureau, as the Purchasing Agent.

METHODS AND COSTS OF DREDGE EXCAVATION OF DRAINAGE DITCHES.

By D. L. Yarnell, Drainage Engineer, U. S. Department of Agriculture.*

The cost of dredges advances rapidly as the size and capacity are increased. Dredges of the same rated capacity also vary somewhat in cost with the different manufacturers. All of the machinery is usually made at the shops of the manufacturer. The material for the hulls may also be supplied by the manufacturer, but usually the purchaser obtains lumber in the open market and builds the hull in the field. The cost of hauling the material and machinery from the railroad to the place of erection, the local price of labor, and the conveniences for housing and feeding the workmen are factors which will enter into the cost of a machine of any type. It requires at least two cars to transport the material for a small dipper dredge, while for a machine of large size from four to six cars are required.

The following table gives the approximate costs of the various sizes of dredges ready for operation, though these would be largely affected by the difficulties and expense of transporting the material and assembling the machine:

APPROXIMATE COSTS OF DIPPER DREDGES.

Size.	Cost of machinery.	Cost of wood hull.	Total.
¾-yard	$ 3,700	$1,300	$ 5,500
1-yard	5,400	2,200	7,600
1¼-yard	6,100	2,250	8,350
1½-yard	7,100	4,500	11,600
2½-yard	14,000	9,000	23,000

It requires practically a month for ten men to erect a 1-yard dredge, six weeks to erect a 1½-yard dredge or 1¾-yard dredge, and eight weeks to construct a 2-yard or 2½-yard machine. It requires less than one-half the time given above to dismantle a machine. A 1-yard dredge which cost $8,000 was shipped about 400 miles and hauled by wagon 18 miles. The dismantling cost about $490; the freight charges were about $700; hauling, $360; and rebuilding about $670. These costs are fairly representative for this size of machine.

Method of Operating.—With a floating dredge the construction should, where practicable, begin at the upper end of the ditch and proceed downstream. Sometimes it is not feasible to transport the machinery and material to the upper end of the ditch and the dredge must then work upstream. This is undesirable, unless the fall be slight, since in working upstream dams must be built behind the boat to maintain the necessary water level. In working downstream the ditch remains full and the dredge, floating high, can dig a much narrower bottom than if working upstream in shallow water. Moreover, when floating low, the dipper may not properly clear the spoil bank. Again, in working downstream, any material dropping from the dipper into the ditch will be taken out in the next shovelful; whereas if working upstream any material dropped or any silt washed behind the dredge is left to settle in the bottom of the ditch. If work is begun on the natural ground surface a pit must be dug to launch the boat; or if in a stream, it may be necessary to build a temporary dam in the channel to raise the water high enough to float the boat. The depth of water required varies from 2 ft. upward, depending on the size of machine.

The floating dipper dredge moves itself ahead by means of the dipper. The spuds are first loosened from their bearings and the dipper is run ahead of the machine and rested on the natural ground surface in front of the ditch. The spuds are then raised and the engines operating the backing drum are started; the dredge, being free, is thus pulled ahead. The spuds are then lowered and excavation continued.

In timbered country the right of way must be cleared. In many cases the timber cut will supply sufficient fuel for the dredge. It is poor policy to fall the trees and leave them on the ground to be removed by the dredge. The stumps should always be shattered with dynamite, as the strain on the machinery is thus rendered much less and the life of the dredge increased.

An engineer, a craneman, a fireman, and a deckhand are required to operate a dipper dredge. The output, loss of time due to breakdowns, and the cost of repairs, depend almost wholly upon their skill and efficiency. The engineer should be an all-around mechanic as well as experienced in dredging.

The amount of fuel consumed depends upon the size and type of boiler used, and upon the burning and heating qualities of the fuel. A very great saving can be effected by covering the boiler with an asbestos coat. Ordinarily, about 25 lb. of coal per horsepower-hour are consumed on dredges. The cost of repairs depends largely upon the operator; a careless operator will cause many unnecessary breakdowns. It is not only the high cost of repairs for machinery but also the time lost which aids in increasing the actual cost of the output. It is a well-established fact that it is not the initial cost of a dredge or of any machine, but the operating and overhead expenses, that reduce the profits.

Cost of Operation.—The cost of dredge work depends upon a number of factors. The locality of the work, the kind of soil, repairs, delays, labor, etc., greatly influence the actual cost of any work. If the water level can naturally be maintained within a foot or so of the surface of the ground, the cost of excavation can be reduced very low with this type of machine. The data given in the following pages were obtained from the actual cost records of the various projects. Unfortunately, the figures are not always strictly comparable, one project with another, owing to variations in the items of cost included. Unless otherwise stated, interest is taken at 6 per cent and depreciation at 35 per cent per annum on the cost of the dredging outfit. Interest and depreciation are, however, charged only for the interval of time upon which the unit cost is based. This is not strictly correct, as a certain amount of time consumed in getting the machine on and off the work should be charged to each project. In most cases it was impossible to ascertain the time that should be charged to moving, building, etc., and therefore the item has been ignored in all cases, for the sake of uniformity. On some projects figures for operation over an extended period were not obtainable. In such cases the unit cost is based upon the daily cost of operation and the average amount of ditch dug per day, no allowance being made for interest and depreciation.

In the construction of a ditch in North Carolina a new 1¼-yard dipper dredge was employed. This dredge had a 5x20x70-ft. hull and was equipped with 8⅜x10-in. double-cylinder hoisting engines; 7x7-in. double cylinder, reversible swinging engines; a 50-hp. Scotch marine return-flue boiler; a 1¼-yard dipper, 31-ft. dipper handle, and 45-ft. boom. The spuds were convertible to bank or vertical and were operated by the hoisting engines. The cost of this dredge, erected, was $10,342.19. The dredge was operated continuously, each shift working 11 hours per day. The men were paid at the following rates per month: Superintendent in charge, $110; engineers, $100; cranemen, $60; firemen, $48; deck hands, $36. The men furnished their own subsistence. The ditch was 9½ miles long and ranged from 22 to 30 ft. wide on top and from 8 to 10 ft. deep; it had side slopes of ½ to 1 and a berm 8 ft. wide. The water level was easily maintained near the ground surface. Very little right-of-way clearing was required. In the construction of this ditch the dredge excavated 350,720 cu. yd. of earth. One year was required for the dredge to complete this work. The following cost data were taken from the records of the drainage district which owned and operated the dredge:

---

*Extract from Bulletin No. 300, Office of Public Roads and Rural Engineering, on "Excavating Machinery Used in Land Drainage."

Cost of operation, including labor and fuel	$15,889.01
Repairs	1,948.21
Interest and depreciation	4,240.22
Total	$22,077.47

Cost per cubic yard, $0.0629.

A new dredge of the same size and type as the one just described was used in the excavation of a drainage ditch in the same locality as the foregoing project. The ditch followed an old creek channel for the greater part of its length. The cost of the dredge, erected, was $9,365.34. It was operated in one shift of 11 hours; the actual time of operation was not recorded. The crew and the rates of pay were the same as in the foregoing example. The ditch was 3¾ miles long and ranged in top width from 22 to 26 ft. and in depth from 6 to 10 ft. The side slopes were ½ to 1; the berm was 8 ft. wide. The dredge worked downstream and the water level was easily held near the ground surface. Practically no right-of-way clearing was done. The material excavated was a loam top soil underlain by stiff clay; very little rock was encountered. The cost of the work was considerably affected by the expense ($1,459) of passing three bridges. The total amount excavated in a period of about 10 months was 121,200 cu. yd. The dredge was owned and operated by the drainage district. The following costs were recorded:

Cost of operation, including labor and fuel	$ 5,921.05
Repairs	1,028.73
Incidentals	117.95
Interest and depreciation	3,199.80
Total	$10,267.53

Cost per cubic yard, $0.0847.

A dipper dredge with a 5½x16x60-ft. hull, 7x8-in. double-cylinder hoisting engines, friction swing, 1-yard dipper, 35-ft. boom, and telescopic bank spuds was used in the construction of about 5 miles of ditch in western North Carolina. No reliable information was available as to the amount of material moved; but the following figures as to the cost of installing the dredge are of interest:

Hull: Labor and material	$1,803.23
Machinery:	
Material	4,800.00
Freight	379.10
Drayage	72.60
Installing	310.60
Extra equipment (forge tools, etc.)	80.00
Lighting equipment (engine and dynamo and wiring)	207.00
Total	$7,652.53

In Colorado, a dipper dredge having a 24 x 75 ft. hull, 1½-yd. dipper, and 50-ft. boom, was used in cleaning out and enlarging about 20 miles of canal. The equipment, complete, including cook and bunk boats, cost $16,500. Two shifts of 11 hours each were run. During the year for which the data are given the dredge was actually in operation but 187 days, or 58 per cent of the total working days. The following crew were paid the given rates per month, including board: Head runner, $120; 1 runner, $110; 2 cranemen at $55; 2 firemen at $45; 2 deckhands at $40; 1 teamster, $40; 1 cook, $50. No right-of-way clearing was required. The water for the boiler was taken from the canal, and as a result considerable trouble was experienced from mud and scale. The cost data below are based on the amount of material moved from inside the grade stakes during the year, amounting to $394,387 cu. yd. It was estimated that an excess of 25 per cent was actually moved. The following was the cost of the work for one year:

Operation:	
Labor operating dredge	$ 6,243.70
Coal, including freight, 1,276.65 tons, at $2.35	3,000.13
Hauling coal, 1,276.65 tons, at 82½ cents	1,053.24
Oil, waste, and miscellaneous supplies	692.80
Cost of controlling water to float dredge	369.24
Repairs, labor, and material	3,894.67
Removing and replacing bridges	837.78
Interest and depreciation	6,765.00
Total	$22,856.66

Cost per cubic yard, $0.058.

Miscellaneous expenses:	
Engineering and supervision	$ 1,856.10
Building up ditch bank and making road on top	4,721.75
Right of way and legal expenses	190.42
Total	$6,768.27

The cost of the dredging outfit was as follows:

Hull:	
Material	$ 1,960.83
Labor, including hauling	1,959.99
Machinery:	
Cost, including freight	9,997.72
Hauling and installing	817.66
Cook and bunk boats:	
Material	663.90
Labor	453.66
Equipment	646.35
Total	$16,500.00

In connection with a drainage project in southwest Louisiana a steam-operated, floating dipper dredge, equipped with a 1-yd. dipper, 40-ft. boom, and convertible power spuds was employed in the excavation of about 10 miles of ditch which varied in width from 18 to 50 ft. and in depth from 4 to 6 ft.; 15-ft. berms were specified. The cost of the dredge on the work is said to have been $10,000. Two shifts of 10 hours each were run, but the actual number of days of operation was not recorded. The crew and monthly rates of pay, including subsistence, were as follows: Two runners, at $100; 2 cranemen, at $60; 2 firemen, at $60; 1 deckhand, $40; 1 cook, $30. The material excavated was a hard, stiff clay. The total amount excavated in about 8 months was 147,000 cu. yd. The average cost, per month, of operation was as follows:

Labor	$ 510
Board	100
Coal	262
Repairs	200
Oil and supplies	50
Interest and depreciation	342
Total	$1,464

Cost per cubic yard, $0.0796.

On another project in southern Louisiana there was employed a floating dipper dredge with a 5 x 22 x 73-ft. hull; 8 x 10-in. double-cylinder hoisting engine; 6 x 8-in., double-cylinder reversible swinging engines; 1¼-yd. dipper, and 40-ft. boom. The machine was equipped with bank spuds. The cost of the dredge, ready to operate, was $13,000. The ditches averaged about 30 ft. wide and were from 5 to 6 ft. deep. The land was nearly level and the water surface was easily kept within a foot of the ground surface. The material was a top muck underlain by an alluvial mud which was hardly solid enough to hold its shape when dropped from the dipper. There were few submerged logs or stumps. The dredge was operated the year around for two years. No record was kept of the actual time of operation. The average output per shift (12 hours) on a 30-ft. ditch 5 ft. deep was 1,200 cu. yd., at a cost as follows:

Labor (4 men)	$10.50
Fuel, 6 barrels oil, at $1.75	10.50
Repairs, oil, and grease	5.50
Total	$26.50

Cost per cubic yard, exclusive of interest and depreciation, $0.0221.

In the same general locality as the foregoing case, and under the same soil conditions, a 1-yd. dredge which was, except in respect to capacity, equipped similarly to the above-described machine, was operated in the construction of ditches which averaged 30 ft. wide and 5 ft. deep. The cost of the dredge, erected, was $11,000. The average output per 12-hour shift during a 2-years' run was 1,000 cu. yd. The cost per shift was as follows:

Labor (4 men)	$10.00
Fuel, 5 barrels oil, at $1.75	8.75
Repairs, oil, and grease	5.50
Total	$24.25

Cost per cubic yard, exclusive of interest and depreciation, $0.0242.

In another drainage project in southern Louisiana several ditches, each three miles long, were constructed by a dipper dredge installed on a 5½ x 18 x 70-ft. hull. The power was obtained from a 60-hp. internal-combustion engine. The dredge had a 1¼-yd. dipper, 40-ft. boom, and convertible power spuds. The total cost of the outfit, including house-boats and small towboats, was $12,000. Two shifts of 10 hours each were run for 26 days in each month. The crew were furnished subsistence, and each shift consisted of: One runner, at $125; 1 craneman, at $65; and 1 engine tender, at $40 per month. One cook, at $35, and one general utility man, at $60, were also employed, making a total labor cost of $555 per month. The average dimensions of the ditch were: Top width, 25 ft.; bottom width, 18 ft.; and depth, 8 ft. The ground was nearly level and the water stood about 3 ft. below the ground surface. The excavated material was a stiff, sandy clay. About 3.4 miles of the work consisted in cleaning old channel, which required frequent moving and gave small yardage. The total excavation in five months was about 216,000 cu. yd. The cost was as follows:

Labor and bcard	$3,555
Fuel and oil	2,300
Repairs	980
Interest and depreciation	2,050
Total	$8,885
Cost per cubic yard, $0.411.	

A steam-operated floating dipper dredge, mounted on a 5 x 15 x 60-ft. hull and equipped with a 1-yd. dipper, 38-ft. boom, and inclined telescopic bank spuds, was used in the excavation of about 10¾ miles of ditch in North Carolina. The cost of the dredge is stated to have been $6,613.82. One shift of 10 hours per day was run. The actual number of days of operation was not recorded. The crew and rates of pay were as follows: One engineer, $125 per month; 1 craneman, $2 per day; 1 fireman, $1.25 per day; 1 watchman, $1.50 per day. The crew furnished their own subsistence. The ditch was about 18 ft. in top width, 12 ft. deep, and had ½ to 1 slopes. It followed an old creek bed for a large part of the distance. The material excavated was a clay, though some rock was also encountered. Based upon the given dimensions of the ditch, the total excavation amounted to 295,000 cu. yd. Eighteen months were required to complete the work. The cost was as follows:

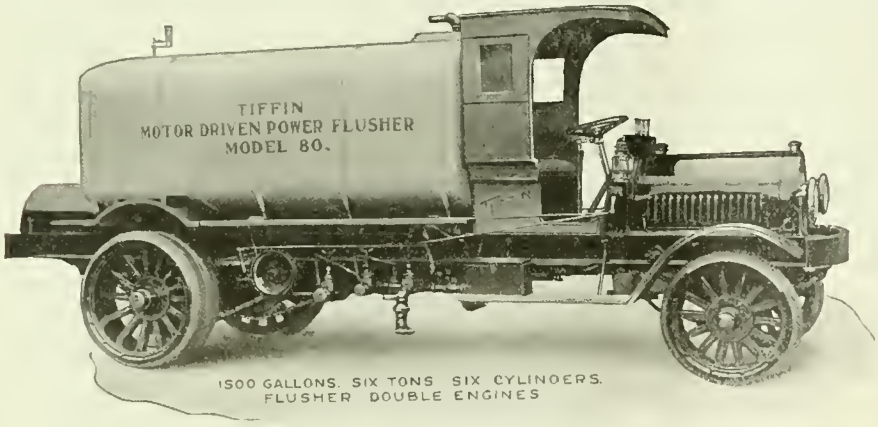

TIFFIN
MOTOR DRIVEN POWER FLUSHER
MODEL 80.
1500 GALLONS. SIX TONS SIX CYLINDERS.
FLUSHER DOUBLE ENGINES

Fig. 1—New Type of Tiffin Motor-Driven Power Flusher.

Operation:	
Labor	$ 6,310.94
Fuel	2,210.30
Repairs:	
Labor	1,380.12
Material	1,136.71
Interest and depreciation	4,067.09
Total	$15,105.07
Cost per cubic yard, $0.0512.	
Miscellaneous expenses:	
Engineering	$ 164.83
Clearing right of way	282.70
Rebuilding bridges	104.96
Incidentals	48.77
Administration	618.00
Total	$ 1,219.26

A TWO-MOTOR STREET FLUSHER.

The illustration, Fig. 1, shows a new type of motor street flusher built in capacities of 900, 1,000, 1,200, 1,400 and 1,500 gal. All these machines have the distinctive features of two power plants, one motor for propelling the vehicle and one motor to supply the water pressure for flushing. The advantages of this construction are explained as follows:

This arrangement allows any desired water pressure to be maintained, regardless of the truck speed along the street. The vehicle may be accelerated or slowed up at the operator's will, in accordance with the condition of the street or grade over which the truck may be traveling, without in any way affecting the water pressure which is controlled by the independent motor at the rear. With motor-driven flushers using one motor both for traction and water pressure, the speed of the truck must remain constant in order to maintain a uniform water pressure. To give the truck a slower pace and still maintain a high water pressure it would be necessary to shift into a lower driving gear. Tests have proven that the latter method does not give the fullest satisfaction because it cannot be accomplished with the precision or efficiency that the two-motor system gives. It is further shown that the two-motor system is more economical in operation owing to the fact that the extra horse power required for operating the water pump need not be provided for in the vehicle motor. This works out as a saving because of the fact that in getting to and from the locations to be flushed the vehicle motor only is operated. The flusher motor is started only when the actual flushing is done.

Another feature is that the propelling and water pressure systems being separate the latter together with the tank may be dismantled and the truck used for other purposes during that season of the year when street flushing is an impossibility owing to snow and cold weather.

The vehicle motors on the 900 and 1,000 gal. machines are of the four-cylinder four-cycle type and the 1,200, 1,400 and 1,500 gal. machines are of six-cylinder type with electric starting and lighting apparatus as regular equipment. The smaller capacity machines can also be electrically equipped at extra cost if required.

The motor for water pressure is a four-cylinder Continental of 20-hp., mounted at the rear of the water tank. Through a 2½-in. centrifugal pump it is capable of delivering 250 gal. of water per minute at a pressure up to 70 lb. Both motors may be started from the seat, since an electric starting and lighting system is a part of the regular equipment of this vehicle.

The discharge nozzles for flushing purposes are so arranged that the entire width of any ordinary street can be flushed at one operation moving in one direction down the center of the street. There are four nozzles, two on each side—both forward and amidships—that can be operated singly or in any combination. Sprinkling nozzles are also provided, being readily interchangeable with the forward flushing nozzles, so that the same machine can do both power flushing and gravity or power sprinkling. Operating the sprinkling nozzles with power pressure gives much more spread to the streams than by the customary gravity pressure sprinkling.

An additional provision is made for an attachment for drawing the water supply from rivers or creeks, where hydrant filling is not available.

The flushers are made by the Tiffin Wagon Co., Tiffin, Ohio.

Federal Aid for State Roads.—By a vote of 281 to 81 the House of Representatives at Washington has passed what is called the "Shackleford Bill" carrying an appropriation of $25,000,000 to aid the states in improving their public roads used in the postal service of the government. The bill as it passed the House provides that in certain cases, clearly defined in the bill, the Secretary of Agriculture shall aid the states in the construction and maintenance of rural post roads, which means "any public road over which rural mail is, or might be, carried outside of incorporated cities, towns or boroughs having a population exceeding 2,000." The expense of administering the fund thus provided is to be paid out of the fund. Each state is to receive outright the sum of $65,000 and one-half of the remainder to be divided is to be apportioned among the states according to population and the remaining half according to the mileage of rural free delivery routes to the extent that such population and rural free delivery routes bear to the population and free delivery routes of all the states.

Engineering and Contracting

Devoted to the Economics of Civil Engineering Design
and to Methods and Cost of Construction

EDITORS

H. P. Gillette C. S. Hill C. T. Murray S. C. Hadden C. W. Malcolm

Volume XLV. CHICAGO, ILL., FEBRUARY 9, 1916. Number 6.

A NOTABLE ARTICLE ON CONCRETE SHAFT LINING CONSTRUCTION.

The second article of the previously announced series reviewing the notable developments of a decade in concrete construction methods is published in this issue. This article describes and discusses concreting methods and form construction and handling in lining shafts. In ten years progress in this use of concrete has been enormous. Indeed, it is not an exaggeration to assert that in barely a dozen years concrete as a material for permanent shaft lining has become standard in America. Of the several features of concreting practice discussed and described in this article one, at least, is worth separate emphasis here. This practice is the successful vertical chuting in small pipes of concrete to depths exceeding a thousand feet. Not many years ago a proposal so to place concrete would have been given short shrift by concrete experts. One brought up in the old traditions will almost certainly regard it askance even now. Yet we have these samples of successful work done, and they will not be ignored.

THE DANGER TO CONTRACTORS FROM RISING PRICES AND WAGES.

Just prior to the panic of '93 the writer had taken his first contract. As a result of the panic he was able to secure men and materials at lower rates than he had estimated. But in '97 he faced a different condition. The curve of prices was about to rise, and in '98 it rose at a rate that robbed almost every contractor of his prospective profits.

A similar rise in prices and wages seems imminent now. Wages of common labor are already going up, for the war has stopped immigration. The flow of gold to this country will eventually find reflection in rising prices. Hence there will be a combination of scarcity of men and plethora of money, a combination certain to cause a rise of wages.

The Steel Corporation has just advanced the wages of its employes 10 per cent, an action that unquestionably will be followed by many other manufacturers, and possibly by the coal mining companies.

He who bids very low on large construction jobs at this time risks a great deal.

AGAIN THAT STEEL MARKET.

That this country no longer is an isolated unit—a unit having control of things within in its own hands—is emphasized very forcefully by the present condition of the steel market. Although steel production has continued to increase month by month, and notwithstanding the greatly increased price of steel, prospective consumers are finding it increasingly difficult to place their orders for near future delivery and are facing a condition which cannot but act as a great deterrent to construction work which otherwise promises to be record-breaking. It is somewhat difficult for those who have not tried to place steel orders to realize that prices are half again and in some cases twice as high as they were a year ago. Moreover, with a volume of business over double that which obtained late in 1914, it is clear that a price level has not yet been reached.

Although present conditions are dependent to a considerable extent on war orders, there is little doubt that domestic demands are sufficient to bring about a healthy condition in the steel market. Some time ago warning was given our readers that delay in ordering steel for future work would prove costly—the same warning still applies with even greater force, as time of delivery—not price—is now the governing factor. Notwithstanding the tendency of steel mills to resist booking any orders for delivery before the latter part of the year, persistent inquiries for near delivery continue, even though the mills are at present running behind in the orders which they now have booked. It now appears that many second quarter orders will be forced into the third quarter. Deliveries on orders now placed can hardly be promised with any degree of certainty before 1917-price not being a consideration. We again urge that those contemplating construction during 1917 place their orders at once, as there is little likelihood of any easement in the steel market before that time.

THE CATALOGING OF AVAILABLE ROAD MATERIALS.

Nature exhibits many vagaries in her location of materials suitable for road building. Gravel and rock and sand and clay of good quality for road construction exist in practically every state but frequently these deposits are so limited in area and distribution that their utilization is circumscribed by a very small arc. The road builder generally must consider the cost of his materials as well as their quality technically. Considering the latter quality alone there can be no doubt in choice as a source of crushed rock for road construction between the trap dike on one state line and the friable limestone outcrop on the opposite state line but economically the trap quarries are more often than not excluded from thought in the limestone region as a competitive source. These differences are not solely state wide; they exist between county and county and often between one pit or quarry and another pit or quarry in the same township. These statements are obviously elementary but they lead to a recognition of a valuable service being widely performed by State experiment stations and State road commissions.

The testing and scheduling of deposits of materials suitable for road construction is now an established procedure in most states. In some the work is performed by the State Highway Commission and in others it is the task of the State University Experiment Station. In all states the general intent of the work is to locate and catalog local deposits with a statement of their quality as determined by tests. Naturally the methods differ in detail. Also as yet the cataloging is incomplete. In a very short time, however, with a continuation of the progress now being made, there will be many states in which there will not be a township whose road building gravel and stone deposits are not located and appraised in order of quality.

The aid that this cataloging gives the road builder is evident. By it he is informed first, if many materials are available, which is the best. If local deposits are poor, the road builder is informed of the nearest deposits of better quality and he can determine the economic propriety of importing the better material. Again, the local road official, the quarryman, the owner of a gravel pit has in the existence of these testing bureaus a means of securing the quality appraisal of his materials.

The road official can thus purchase and the quarryman or pit owner can sell a certified product. These are advantages of importance. Altogether the State road materials testing and recording bureau is deserving of hearty support.

CONTROL OF CONCRETE MATERIALS IN AQUEDUCT CONSTRUCTION.

All materials for concrete used in the Catskill Aqueduct were provided by the contractor under specification and subject to test. In receiving bids for construction the aqueduct engineers required separate prices for cement per barrel and for concrete masonry per cubic yard. By these two means direct control was sought over materials for and composition of concrete. The separate bid for cement permitted the engineers to vary at will the proportion of cement per unit of concrete. Careful specification of quality, proportions and granulometric composition of aggregates with prohibition of the use of any but tested materials gave control of the aggregates.

The Winnipeg Aqueduct now under construction more nearly resembles the Catskill Aqueduct in type, length and dimensions combined than does any other aqueduct of contemporary times. All materials for concrete used in this Canadian structure are supplied by the municipality. An article on another page describes the methods of supply. Briefly, the cement tested is delivered to the contractor at cost to the municipality. The contractor is charged for the cement delivered and credited with the cement used. The aggregates proportioned and mixed are delivered to the contractor at a fixed cost per cubic yard. The aqueduct engineers then stipulate the volume of cement to be used per cubic yard of concrete. These means give the engineers direct control of all concrete materials.

These two examples are not cited for the purpose of comparing the merits of the two methods of control. Without many more data than are available no comparison of value is possible. The citation is made to exemplify a practice that is becoming more and more firmly established, looking toward direct control by engineers of materials used in making concrete. Naturally as yet the practice is limited to works for which either a large volume of concrete or concrete of exceptional properties is demanded. Of such works large aqueducts are notable examples because of the importance of exceptional quality in all concrete entering into their construction.

TRAFFIC REGULATION ON STREET DECKING IN SUBWAY CONSTRUCTION.

Construction of subways under city streets as in New York and Boston requires the use of a decking to replace the street surface during excavation for and erection of the subway structure. Often in narrow streets the full width, including sidewalks, is replaced for considerable periods of time by this decking. At best the conditions of construction are onerous, but they are frequently and rather thoughtlessly made extra-onerous by neglect of any traffic regulation over decked sections of streets by the traffic authorities. This is a factor whose importance is seldom given notice in plans for subway work. Generally the city takes no other concern than to stipulate that a decking shall be employed which will assure the convenience and safety of the surface traffic; the contractor is left to take all chances of what this surface traffic shall happen to be.

It is apparent that with any practicable system of decking construction the decked section must be the weak part of the street. At most then it should not be expected to endure greater than normal every-day traffic. Indeed some extra restriction of this normal traffic is justifiable. Contractors for subway work are witnesses that in neither respect are they customarily favored. One contractor has called attention recently to the heavy loads to which his street decking was subjected—for instance, a traction engine, a steam shovel, and a herd of elephants. And heavy loads are not the only trouble. Speed of travel, often more dangerous than mere tonnage of load, is unrestricted. Fire fighting apparatus in particular is given as free control of the decked street as of any other. With all due consideration to the users of streets, no sound excuse exists for such uses of decked streets as have been named. They are never less than hazardous uses. Always they are extravagant uses because the contractor fearing their possibility must put extra cost into his decking and this cost appears in his price for construction. With a very little planning by traffic officials such uses are unnecessary, and it would seem to be the business of these officials to do such planning.

ALLOY STEELS.

The advances made during the past few years in the commercial production of the various alloy steels have been so marked that engineers have generally been unable to keep pace with them; in fact, few engineers who have not made a specialty of steels can claim a working knowledge of the alloy steels now being produced. Among the more useful alloy steels may be mentioned: nickel steel, manganese steel, tungsten steel, chromium steel, silicon steel, nickel-chromium steel, chromium-vanadium steel, and various kinds of high-speed tool steels. By alloy steel is here meant a steel which contains one or more elements other than carbon in sufficient proportion to modify or improve substantially and positively some of its useful properties.

At various times in the history of steel making most elements that could be produced in sufficient quantity have been alloyed with iron in various proportions, but only a few elements have been found to exert a useful influence in the commercial production of steels. With a very few exceptions all alloy steels are heat treated for use, this heat treatment developing in them the high physical properties which they possess. Heat treatment, although an exceedingly important factor in the production of alloy steels, has a very different effect on each kind of steel—some steels when quenched from a high heat are hardened, and others are softened. In general, heat treatment may be said to have contributed more to the superior qualities of the steel than has the use of alloys. The modulus of elasticity of many, if not all, structural alloy steels is not changed to any considerable extent by heat treatment or by variation in composition, usually ranging between 28,000,000 and 30,000,000 lb. per square inch; the elastic limit and ultimate strength, however, may be doubled or trebled. Probably the two alloy steels best known to structural engineers are nickel steel and manganese steel, the former being used to a considerable extent for bridge work and the latter for rails and machinery parts.

To make more readily available our present knowledge of alloy steels, and to stimulate the demand for such steels as have practical use, the Department of the Interior, Bureau of Mines, has recently issued a bulletin—No. 100—in which the manufacture and uses of alloy steels are treated in detail. The information given is of practical value, and engineers should avail themselves of this opportunity to secure a better knowledge of alloy steels. Heretofore information has been difficult to obtain, as it was considered in the nature of a trade secret by the manufacturers.

KEEPING UP WITH THE MANUFACTURER.

We were reminded on reading a review of a recently published work, on a special branch of civil engineering, that it is very easy for the user of machines to get out of touch with the improvements in the special lines of machinery of most frequent application in his work. The book was praised in the highest terms on all points except those relating to the machinery utilized by the class of engineers addressed. In its treatment of this special line of machinery the book is conspicuously behind the times. The descriptions and illustrations of some of the antiquated types of apparatus used in a former edition of the work are repeated in the latest edition to the exclusion of similar matter pertaining to the latest types of machines which under service conditions have demonstrated their superiority over the older types. Much space is also given over to a treatment of a nearly obsolete form of a very important mechanical detail. In general the new machinery is slighted in favor of the old, thus marring the author's otherwise highly commendable work.

The book writer we mention is not a mere theorist but is a very successful practicing engineer as well. This is an important point since it emphasizes the fact that an engineer can do acceptable work, aside from economic considerations, with machinery which is obsolescent. Machinery has been well developed for a long time and the old types still work as well as they ever did—in fact they work very well indeed and it is only when they are compared with modern types that they appear to a disadvantage.

Thus there is a constant temptation to the engineer to stand pat on his knowledge of machinery. The danger of this attitude of mind toward mechanical developments is forcefully illustrated by considering the agricultural appliances still used in some remote corners of the world. It behooves the engineer to keep in touch with the developments in the machinery used in his field lest he appear as one who plows the ground with a crooked stick.

Two million automobiles in the United States, and half a million auto eggs in the 1916 incubator. This presages "more work for the undertaker," perhaps, and certainly more work for the road builder.

Herbert C. Hoover, American civil engineer, executive in charge of the American Relief Society in Belgium, is one of the many engineers who are proving that a technical education does not necessarily make a narrow man.

The world has stood agape at "German military efficiency." How many men, even among well-read Americans, have asked themselves where most of that "efficiency" would have found vent had there been no American inventions of engines of war. To name but a few: The aeroplane, the telephone, the telegraph, the submarine, the armor-clad warship, the gasoline automobile, the breech-loader, and the army mule. The last named stands not least among the original products of our own "late unpleasantness" as an "engine of war."

While on the subject of inventions, who knows the name of the inventor of the wheel-scraper, or wheeled-scraper? There was a real genius, if genius be marked by effective simplicity of product. He put two wheels on an old dust pan, "and b'gosh it ran." And it ran so well that millions of yards of "dirt" have walked from their ancient, useless resting places into new and useful levees and railroad fills.

The engineer's pride is that more than most men he has served the public conspicuously in inconspicuous ways. An award of honor for inconspicuous public service is provided for by a gift by Mr. John W. Alvord, consulting engineer, of Chicago. The Western Society of Engineers is trustee of the fund and will award the medal from time to time, as the occasion arises. In these days, when men throughout a large part of the world are receiving medals for conspicuous destruction of life and property, provision of an award of honor for inconspicuous labor toward conserving life and the material things that make living pleasant is a particularly fitting action.

Slowly but surely the public is discovering the engineer. One piece of evidence leading to this conclusion is the growing tendency of public speakers and professional writers to mention the engineer along with doctors and lawyers when referring to learned men. Once it was doctors, lawyers and preachers—now the engineer is beginning to take the preacher's place in this particular if in no other. Thus does example triumph over precept.

METHODS AND COSTS OF CONSTRUCTION OF CONCRETE PAVEMENTS AT TONAWANDA, N. Y.*

By A. F. Comstock, Associate in Railway Engineering, University of Illinois.

The concrete pavements here described were built during the summer of 1914 for the city of Tonawanda, N. Y.,—a city of 10,000 people, located in western New York between Buffalo and Niagara Falls. Two pavements were constructed, intersecting at right angles. One, on Morgan St., was 30 ft. wide between curbs, and was approximately one mile long; the other, Clinton St., was 48 ft. wide, with an 8-ft. parking in the center, and one-half mile long; 21,300 sq. yd. of pavement, and 17,300 lin. ft. of combined curb-and-gutter, comprised the total quantities. Both streets lie in an old, thickly settled residential part of the city, abounding in shade trees, and substantial homes. The traffic is moderate in amount and of a local character.

The decision to use concrete was made by the Board of Public Works in 1913, after a committee had made a trip of inspection to Wayne County, Michigan, and had reported favorably upon the feasibility of concrete for the conditions existing at Tonawanda. Low first cost and permanence were inviting characteristics of concrete, and these considerations, combined with such favorable conditions as a gravel sub-soil underlying both streets, and an excellent grade of sand and crushed stone available, made concrete the favored material.

Preliminary Study.—Recognizing that many of the details of concrete pavement were yet undeveloped, considerable study was devoted to the design and specifications. Little had been done previously with concrete pavement in western New York. What few concrete pavements had been built in the neighboring country had injured rather than enhanced the reputation of that material. The engineers were especially anxious in this instance to insure concrete a fair trial, since they were convinced that previous failures in the vicinity had been due to faulty design and inspection, rather than to inherent weakness of materials.

Sand and Stone.—Exceptionally high-grade sand and limestone were accessible. The sand is known as "Niagara grit," and is dredged from the Niagara River. It is clean and rather coarse, running to ¼-in. pebbles. The stone is called "Niagara limestone." It is hard, and contains considerable flint.

Proportions of Concrete.—In deciding upon the proportions of ingredients in the concrete, a conclusion was reached which some engineers may regard as questionable. A 1:2:4 mixture was thought to be sufficiently rich for the pavement, although it was felt that a 1:1½:3 concrete would give slightly better qualities. We were aware, however, that the tendency always is, despite efficient inspection, toward a leaner mixture than the one specified. We decided, therefore, upon a 1:1½:3 concrete, and this is the mixture we strove constantly to obtain; except that after the work began the ratio of sand to stone was slightly increased, keeping the total quantity of aggregate the same (4½ cu. ft.), in order to make possible a better finish.

Thickness of Concrete.—The pavement was made 6 in. thick over the full width; and a circular crown equal to one one-hundredth of the width was adhered to in both the surface and sub-grade. Wire reinforcement (No. 29 American) was placed 2 in. from the top of pavement. Its cost, which was less than 8 ct. per square yard, was thought to be justified as an added precaution against cracks.

Expansion Joints.—Expansion joints were located at 33-ft. intervals at right angles to the pavement; and a longitudinal joint was placed along the middle of the 48-ft. pavement, between parkings. The Baker steel joint was used, with a ⅜-in. strip of felt between the plates; while a felt strip ⅜ in. thick without steel was used along the gutters.

---

*Paper read before the Annual Meeting of the Illinois Society of Engineers and Surveyors at Urbana, Jan. 26-28, 1916.

Combined Curb-and-Gutter.—The curb-and-gutter consisted of a 6-in. curb 12 in. high, and an 18x6-in. gutter, all on 6 in. of tamped cinders. There is no doubt that the joint between gutter and pavement is a source of weakness and possible future trouble, particularly at street corners. On the other hand the gutter makes possible a superior pavement surface because of the increased facility of operating the strikeboard. A 1:2:4 concrete was used for the curb-and-gutter, with a facing of 1:2 mortar 1 in. thick. Expansion joints were formed by steel plates 6 ft. apart, withdrawn before the concrete had taken final set.

Contract Prices.—The contract was awarded to a contractor who was reliable and of good repute, but inexperienced on concrete pavement. He proved, however, to be entirely willing to co-operate in securing satisfactory work. The contract price, based upon estimated quantities, was approximately $42,500. The unit prices were as follows:

Item.	Quantity.	Price.
Pavement, 6-in. concrete	21,300 sq. yd.	$ 1.44
Curb and gutter, straight	14,200 lin. ft.	0.52
Curb and gutter, curved	3,100 lin. ft.	0.60
Concrete header, 8x18-in.	1,000 lin. ft.	0.26
Receivers, cast iron	44	43.00
Removing old curb	4,000 lin. ft.	0.04
Sewer, 8-in. vitrified pipe	150 lin. ft.	0.60
Sewer, 6-in. vitrified pipe	150 lin. ft.	0.50
Overhead	7,000 cu. yd.	0.01[1]

[1] Cu. yd. per 100 ft.

Inspection.—Despite the willingness of the contractor to co-operate in carrying out the letter of the specifications, the task of inspection was a most exacting one. Education was needed all along the line. Mistakes and carelessness of men had to be guarded against more than willful violation of instructions. Constant and extraordinary vigilance was required to produce the desired results.

Laying the Curb-and-Gutter.—The curb-and-gutter was laid by a separate gang in advance of the paving; 300 lin. ft. of steel forms and the same amount of 2-in. wooden forms were used. The wooden forms cost only one-third as much as the steel, and were handled and reset with the same facility. An inspection of the formsetter's line was made as soon as he had established it from the stakes, with special attention for errors in grade. A final inspection of the forms was made before concreting was begun. Two troublesome features were encountered. One was to prevent removal of the forms before the concrete was hard enough to retain its shape unsupported, and the other was to compel the mortar coat to be applied before the first course had taken initial set.

Fine Grading.—The fine grading was done after the curb-and-gutter was in place. Trouble was experienced in getting the foreman to take sufficient care to insure that the sub-grade, when rolled, was low enough. To guarantee this result, the writer believes that the strikeboard, or some other template having the same crown as the pavement, should be used. After all, this is a vital point, for in case the excavation is not deep enough, and the discrepancy is not discovered until concreting is impending, expensive and exasperating delay ensues. Moreover, the trouble can scarcely be properly remedied under the haste and pressure resulting at such time.

Concreting the Pavement.—A one-half-yard Foote street mixer, equipped with a chute, was employed for the pavement. It gave excellent results. No separation of the ingredients was observed, once the superintendent and the engineers of the mixer were given to understand the exact requirements. What we called a "liver mixture" was insisted upon, which meant just enough water to allow the concrete to flow in the chute. In fact the assistance of a man with a shovel was sometimes needed to keep the concrete moving. Two-bag batches were used, and an average of 720 sq. yd. was laid in a day of eight hours.

The crushed stone was specified to be uniformly graded from ¼ in. to 1 in. Some difficulty was had in obtaining proper grading, as the latitude in size appeared to allow the crusher people too much liberty. One uniform size of stone is much easier to compel adherence to, and it should produce as good wearing qualities in the pavement as the graded sizes.

The method of measuring ingredients was not specified, although the bag of cement was specified to be taken as 1 cu. ft. Accordingly the following method was adopted: Three bags of cement were dumped in a box, the cement shaken down, and a mark made around its upper limit. The cement was then removed and a number of tests were run with different men to determine the number of shovelfuls of sand and stone required to make 3 cu. ft. The men were instructed and observed to take a full shovelful each time. From these tests instructions were issued as to the number of shovelfuls of sand and concrete to be placed in each wheelbarrow. These tests were repeated often enough to maintain a check on results, which were surprising in accuracy. The advantage of the method was that there was no way to increase the amount of aggregate without increasing the number of shovelfuls, and the inspector could stand some distance away, even as far as a block, perhaps, without being misled. Needless to say new shovelers had to be instructed in the method from time to time. Cement bags were counted each night, and at shorter intervals occasionally, to keep the ratio of cement normal.

Mixing was continued for 15 revolutions of the drum, which was found to give satisfactory results. The interior construction of the drum in this type of mixer is unusually efficient, requiring a minimum of time to produce proper mixing.

Finishing the Pavement.—A strike-board with steel edge was used to bring the concrete to finished grade. It was made 16 in. longer than the distance between gutters so as to allow for the sawing action required in operating it. Two finishers followed the strike, working from a bridge which was carried on wheels running in the gutters. Wooden hand floats were used for finishing.

Placing Wire and Joints.—The two best men were detailed to place the wire reinforcement, and set-up and place the joints. Four inches of concrete was first laid the full width for a short distance, and a sheet or two of wire was then placed across the entire width of pavement. Then the rest of the concrete was placed over the wire, before moving the mixer. The wire was ordered in flat sheets long enough to reach from gutter to gutter. Occasionally it would bulge up through the surface of the concrete, requiring heroic measures to subdue it, and force it back into place; but such cases were not nearly so frequent as they usually are with rolled wire.

The expansion joints were recognized as the most difficult part of the construction. To get the steel joints at the exact level of the surface of the concrete or slightly below it, was the aim. The men operating the strikeboard were instructed not to work closer to the joint than 2 ft. but to be sure to leave the concrete around the joint a little high. The clamps holding the several parts of the joint together were left in place for more than a half hour. The finishers were then required to wade in the concrete near the joint, and by the use of a three-foot straight-edge, to cut the concrete down to the level of the pavement adjoining, using the top of the steel joint as a template to support one end of the straightedge. In this way no abrupt changes in level were possible at the joints, and the concrete was made to meet exactly the top of the steel.

Constant care had to be exercised to see that the several operations did not lag too far behind nor approach too near one another. Preemptory orders had occasionally to be given to prevent this, especially when the finishers did not keep up with the concreting.

Street Intersections.—At street intersections stakes were used to fix the level of concrete at the center, and a ten-foot straight edge was used by the finishers to level and prepare the surface for finishing. The eye had to be largely relied upon here in securing a smooth and uniform surface, since the strike-board could not be used. Here again an accurately finished sub-grade was essential.

Earth Covering.—Most of the pavement was covered with earth in the usual way. In places, however, continuous shade made this course unnecessary, and sprinkling at frequent intervals took its place. The temperature seldom exceeded 80 degrees, Fahrenheit.

Detailed Cost Analysis.—Following is a somewhat detailed analysis of cost of the pavement:

SIX-INCH CONCRETE PAVEMENT, PER SQUARE YARD.

Materials:	
Cement, 0.32 bbl. at $1.20 f. o. b. cars	$0.384
Sand, 0.080 cu. yd. at $1.10 delivered	0.088
Stone, 0.14 cu. yd. at $1.21 f. o. b cars	0.169
Wire reinforcement at $0.76 per 100 sq. ft	0.070
Joint material at $0.15 per lin. ft	0.050
Total materials	$0.761
Labor:	
Grading (12 in. of excavation on average)	$0.250
Unloading and hauling cement 0.5 mile	0.032
Unloading and hauling stone 0.5 mile	0.039
Unloading and hauling wire 0.5 mile	0.005
Unloading and hauling joints 0.5 mile	0.003
Mixing and placing concrete	0.111
Spreading and removing earth covering (2-in. thick)	0.008
Sprinkling (for 10 days)	0.005
Total labor	$0.453
Plant and Supplies:	
Mixer rental at $10 per day	$0.02
Fuel, oil and repairs	0.01
Canvas, boots and other supplies and tools	0.02
	$0.050
Overhead	0.050
Total cost, per sq. yd	$1.304
Detailed Labor Cost:	
16 men shoveling and wheeling at $0.20 per hr	$32.00
2 men handling cement at $0.25 per hr	4.00
2 men handling wire and joints at $0.25 per hr	4.00
4 men handling strike-board at $0.25 per hr	8.00
5 men shoveling concrete around chute at $0.25 per hr	10.00
1 foreman at $0.50 per hr	4.00
Engineer and fireman on mixer	6.00
2 finishers at $0.50 per hr	8.00
Superintendent and timekeeper (½ time)	3.75
Total	$79.75
Labor cost per sq. yd = 79.75/720 =	$0.111

Plowing with steam roller in well-compacted road cost $0.01 per sq. yd. for each time over. Two or three times over was the rule.

Rough grading cost $0.18 per sq. yd., exclusive of plowing.

Fine grading cost $0.03 per sq. yd.

Rolling with 10-ton roller cost $0.003 per sq. yd.

The work described in the foregoing pages was constructed under the direction of the writer, acting for the firm of Ellsworth Bros. of Buffalo, N. Y. Weather conditions were, on the whole, favorable. The average rate of progress maintained while working was 720 sq. yd. per day of eight hours. Including delays by rain and repairs, however, the average rate for the entire period was only 500 sq. yd. per day; 864 sq. yd. was the largest day's work.

DESIGN AND CONSTRUCTION OF THE FOLLY HILL RESERVOIR OF THE SALEM, MASS., WATER WORKS.*

By William S. Johnson, Consulting Sanitary and Hydraulic Engineer, Boston, Mass.

In June, 1914, came the great Salem fire which wiped out the buildings in an area of 253 acres, with a property loss of $15,000,000. After the fire everyone realized the importance of a large quantity of water under good pressure. The increased pressure and volume of water have been obtained by the construction of a new reservoir on Folly Hill in Danvers. The old reservoir was at elevation 145 and the main feeder into the city was a 30-in. pipe 5¾ miles in length. The reservoir on Folly Hill will be at elevation 209 and will feed the city through a new 36-in. main 3¼ miles long and a part of the old 30-in. main 4 miles long. The capacity of the new reservoir will be 10,000,000 gal., or one-half the capacity of the old reservoir.

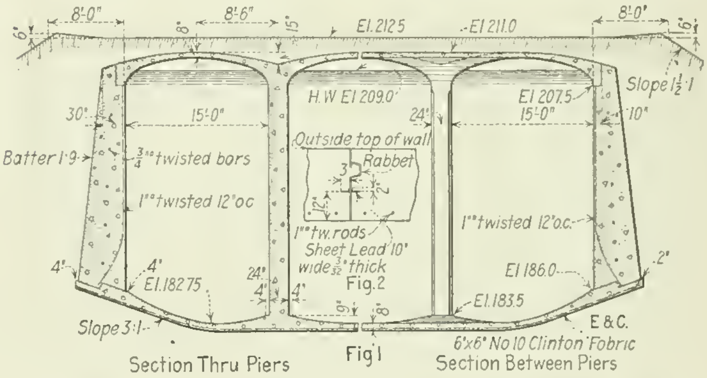
These two pipe lines will be capable of delivering the quantity of water used during the height of the Salem fire with a loss of pressure of about 13 lb. During ordinary consumption the pressures in the city will be increased from about 50 lb., as at present, to about 78 lb.

Folly Hill makes an excellent site for a distributing reservoir, not alone for Salem, but also for the surrounding towns, and when the reservoir is completed Salem will be in a position to help the towns which gave such valuable assistance during the fire. When suitable connections are made, this reservoir will give better fire protection for Danvers and Beverly than can be obtained from their own works, and will be of the greatest assistance to Peabody. It could also be used to supply Marblehead by the construction of a comparatively short pipe line.

The highest point on the hill is elevation 205, but the topography is not what might be desired for a reservoir, being a long narrow ridge. It was desirable to get as great an elevation as possible, and various plans were worked out, including circular tanks, but it was finally decided to construct a 10,000,000-gal. rectangular reservoir with a groined arch roof, high water to be at elevation 209 and extreme low water at elevation 182.75. The dimensions of the reservoir, which were determined by the shape of the hill, are 406 ft. by 134 ft.

The covered reservoir was determined on because the water will at some time be filtered, and while it is somewhat uncertain what the effect will be of storing the filtered water in an open reservoir, it is possible, to say the least, that disagreeable growths of organisms may occur unless the water is protected from the light.

The design of the reservoir is not novel, although in some respects it differs from many of those which have been built, as shown in Fig. 1. The floor is constructed in two layers, the first layer, 5 in. in thickness, being flat and reinforced with 6-in. by 6-in. mesh, No. 10 Clinton welded wire. The upper layer is 3 in. thick midway between the piers and 12 in. thick at the piers. The floor is brought up at the sides, and ends on a slope of 1 vertical to 3 horizontal to about 3 ft. above the elevation of the main floor, and the side walls rest on this. The side walls are 21.5 ft. high to the springing line of the arch. They are 2.5 ft. thick at the top and have a batter on the outside of 1 in 9, the inside face being vertical. The approximate thickness of the wall at the bottom is 5 ft. The floor of the reservoir has a slope of 6 in. from the ends toward the inlet sump at the center.



SOME DESIGN DETAILS OF THE FOLLY HILL RESERVOIR OF THE SALEM, MASS., WATER WORKS.
Fig. 1—Sections of Walls, Piers and Arches. Fig. 2—Plan of Vertical Joint in Walls.

The walls are reinforced to withstand the pressure of the earth embankment when the reservoir is empty. This reinforcement consists of vertical 1-in. square twisted rods spaced 12 in. on centers. At the joint between the floor and the wall, and at all other horizontal joints below the springing line of the arches, there are placed two strips of No. 20 steel, 6 in. wide, to act as dams and lessen the leakage of water through the joints. The vertical joints are made watertight by a bent strip of sheet lead 10 in. wide and 3-32 in. thick, as shown in Fig. 2. The 161 piers are of plain concrete 2 ft. square with a 2-in. chamfer on the corners and are 24 ft. high. They are spaced 17 ft. on centers and rest on bases 2 ft. 8 in. square formed by the floor. On these piers rest the elliptical roof arches, which are 6 in. thick at the crown and have a clear span of 15 ft. and a rise of 3 ft. The roof is depressed 15 in. over the piers. In it are placed 17 manholes with double iron covers.

The earth which was excavated will be placed on the top of and around the reservoir. The depth of earth covering on the top above the soffit of the arches will be 18 in. The embankment will be carried out to a point 7 ft.

---

*From a paper in Journal of the Boston Society of Civil Engineers for January, 1916.

3 in. from the inside of the reservoir walls and will then have a slope of 1½ horizontal to 1 vertical.

On the easterly side of the reservoir is a chamber built on the wall to provide for the overflow. In the bottom of this chamber is a 16-in. pipe leading to a tile drain which discharges at the bottom of the hill.

The gatehouse is to be of hollow tile construction with a surface of plaster and a red tile roof. It will contain, besides the gate stands, the register apparatus for the 36-in. meter which is to be installed just beyond the inlet to the reservoir.

The earth excavation for the reservoir was done by day work in order to provide employment for some of the many men thrown out of work by the fire. About 30,000 cu. yd. of very hard material were removed at a cost of $22,000 or about 73 ct. per cubic yard. The earth removed was placed in the embankments as far as possible and the remaining material was placed in spoil-banks. This is a wasteful method of doing the work, as it means handling much of the material twice, but it was considered advisable not to have the city workmen and the contractors' workmen on the job at the same time, one reason being that the city laborers were paid at a rate of about 35 ct. per hour, while the contractors' men receive about 20 ct.

The contractors for the work are A. G. Tomasello & Son, and they receive the following prices:

Item.	Estimated quantity.	Unit price.
Earth excavation	1,000 cu. yd.	$ 1.00
Earth fill	25,000 cu. yd.	.35
Concrete in piers and arches	2,200 cu. yd.	8.45
Concrete in floor	1,850 cu. yd.	7.00
All other concrete	3,300 cu. yd.	6.30
Reinforcing steel	53 tons	75.00
Gatehouse	Lump sum	1,400.00
Fertilizing and seeding	3 acres	100.00
Appurtenances	Lump sum	700.00

The total price, based on the estimated quantities, is $68,455, not including the work done by the city, which amounted to about $22,000.

COSTS OF DITCH EXCAVATION WITH TEMPLET EXCAVATORS.

By D. L. Yarnell, Drainage Engineer, U. S. Department of Agriculture.*

A single-bucket templet excavator was used in southern Louisiana on the construction of 7,825 ft. of ditch having a 24-ft. bottom width and ranging in depth from 3.5 to 7 ft. The side slopes were 1 to 1, and the width of berm was 15 ft. The total excavation was 43,128 cu. yd. The total cost of this machine on the work was $8,506.22. The soil was a yellow clay with a few spots of gravelly clay, and the top soil was baked very hard. No special difficulties were encountered except that considerable cribbing was necessary to level up the track supporting the excavator when crossing natural water courses; except for these streams the ground was level. Some trouble was also experienced with the traction device, due to the fact that the ditch was larger than that for which the machine was designed. The actual number of working days was 128, 73 days of which were spent in actual digging. The cost of operation per day was as follows: One operator, $3.85; one fireman, $2.28; three deck hands, $6.27; one team and teamster, $5.40. The total cost per day was $17.80. The average daily excavation for the number of days worked was 337 cu. yd. The total cost of operation for 5 months was $3,500.58. Interest and depreciation in that time, at 41 per cent per annum, would amount to $1,452.82, making the total cost $4,953.40 and the cost per cubic yard $0.1149. Table I is an itemized statement of cost for the entire work.

TABLE I.—COST OF OPERATION OF SINGLE-BUCKET TEMPLET EXCAVATOR ON A DITCH IN SOUTHERN LOUISIANA.

Month.	Labor		Material													
	Operation.	Repairs.	Operation.	Repairs.	Fuel.	Total cost.	Excavation, cubic yards.	Cost per cubic yard, cents.	Distance excavated, feet.	Total number days worked.	Actual number days digging.	Average length dug per day, feet.	Maximum length dug per day, feet.	Average depth, feet.	Maximum depth, feet.
February	$ 170.00	$ 26.00	$ 45.00	$ 20.00	$ 55.39	$ 316.39	4,175.9	.076	1,115	16	9.45	120.5	195	3.63	5.30
March	439.75	48.90	141.92	52.63	158.50	841.70	10,559.0	.080	1,785	30	18.7	95.4	140	5.62	7.00
April	306.59	116.31	122.05	91.34	100.00	736.29	7,303.0	.101	1,200	26	10.8	111.1	114	5.57	6.70
May	499.63	46.80	77.69	5.41	156.92	786.45	10,151.2	.077	1,850	29	18.1	102.3	120	5.10	5.80
June	469.27	56.47	109.37	53.61	131.03	819.75	10,938.5	.075	1,875	27	16.3	115.03	135	5.38	6.10
Total	$1,885.25	$294.48	$496.03	$222.99	$601.84	$3,500.58	43,127.6	.081	7,825	128	73.35	106.60	195	5.06	7.00

METHODS OF RESURFACING BITUMINOUS MACADAM PARK BOULEVARDS AT KANSAS CITY, MO.

By Ralph R. Benedict, Assistant Executive Officer.

Resurfacing is accomplished by park forces and consists of placing 2½ in. of crushed limestone on top of the old surface in the following manner: The boulevard is thoroughly swept with a rotary street broom to remove such fine particles of dust and oil as have accumulated. Along each gutter a strip is excavated to such a width and depth as to permit the application of 2½ in. of stone. This stone is native limestone of 1½ to 2 in. in size and is placed on the old surface at least two stones thick, which, after rolling, gives a finished surface of 2½ in. thick. No scarifying or picking is done. After the surface has been sufficiently rolled to thoroughly key the stone, 1½ gal. of asphaltic cement is poured by means of hand-pouring pots. Over this is cast limestone grit of ¼ to ¾ in. in size and rolled. The excess grit is then swept off and a seal coat of ½ gal. of asphaltic cement of the same grade is poured and grit used and rolled as before. This work was done at a cost of about 40 ct. per square yard for the first treatment and 15 ct. for the seal coat. There are a number of these resurfaced boulevards that have been finished for two years and they are in as good condition as when first constructed.

On another boulevard having very heavy traffic the old water bound macadam was excavated to 3 in. below the surface, rolled, water sealed and allowed to dry out. A layer of 1½ in. of granite was spread over the subgrade as previously prepared and into this was cast limestone grit and 2 gal. of asphaltic cement, more limestone grit used and this layer rolled. The top 1½ in. of granite was then placed, rolled and two additional gallons of asphaltic cement used. Over this was cast the granite grit and rolled. After which the excess grit was swept off and the seal coat of ½ gal. was applied.

Another method employed on a limestone macadam road was first to sweep clean with a rotary broom and then break up with a 10-ton spiked roller. This was followed by a scarifier which thoroughly loosened the surface for a depth of at least 6 in. The large sized stones were harrowed to the top by the use of a heavy weight A-shaped harrow. The roadway was reshaped by the use of a common road grader and where necessary new stones added to bring the surface to an even gradient. After this had been thoroughly rolled with a 10-ton roller, 1 gal. of hot asphaltic cement was poured, limestone grit added and rerolled. This construction gave a surface that has been highly satisfactory for the past three years and has not required any maintenance except a light application of oil once a year. This resurfacing work was done at a cost of about 30 ct. per square yard.

---

*Extract from Bulletin No. 300, Office of Public Roads and Rural Engineering, on "Excavating Machinery Used in Land Drainage."

*Extract from Report of Board of Park Commissioners, Kansas City, Mo.

CONSTRUCTION WAYS, MEANS AND COSTS.

Building Railway Embankment With Hydraulic Dredges.—The method described is employed by the Chicago, Burlington & Quincy R. R. for building embankment across sloughs on line rectification along the bank of the Mississippi River. Referring to Fig. 1, where the fill first appears above water, shields 10 ft. long and 2 ft. high are placed on each side as indicated for one side only at a. The sand is allowed to deposit until it is filled in as at b. Sand from inside the shield line is then shoveled over against the backs of the shields on the desired 2:1 slope, and the shields are jacked up as in c. When the fill again nearly covers the shields, the operation is repeated, and again a third time when the fill is about 3 ft. deep as in d. The whole shield line is then moved in about 6 ft., and similar operations follow until the completed embankment has reached grade with a top width of 34 ft. for double track. One foot is the usual allowance for shrinkage, although in some cases more has been deemed necessary. Mr. E. R. Stevens in the "Wisconsin Engineer" states that this dredge embankment is 35 to 50 per cent cheaper than steam shovel work.

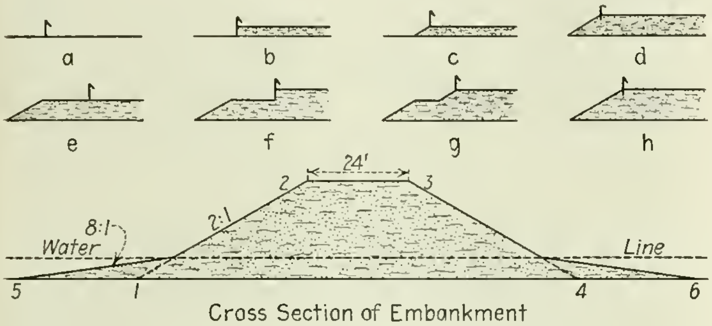


Fig. 1—Building Embankment With Hydraulic Dredges.

Concrete Stoppings for Mine Ventilation.—A stopping in a coal mine is a wall or barrier built in a cross-cut to prevent air from passing through. It is a necessary provision in mine ventilation. Stoppings vary in area but range generally between 50 and 100 sq. ft.; they are built of a variety of materials, including brick, wood, stone masonry, concrete blocks and monolithic concrete. Concrete is the newest of these materials and the following costs of concrete stoppings are given in a recent bulletin of the bureau of mines as determined by averaging a large volume of collected information. The unit assumed is an area of 8x10 ft., or 80 sq. ft. The costs follow:

Monolithic Concrete, 8-in. Wall:	
1.2 bbl. cement at $2	$ 2.40
0.35 cu. yd. sand at 42 ct	0.15
0.95 cu. yd. stone at 50 ct	0.48
Forms, nails, tools, etc	1.50
Total materials	$ 4.53
Delivering, 2 hr. at 32 ct	0.64
Building, 20 hr. at 32 ct	6.40
Total labor	$ 7.04
Grand total	11.57
Concrete Blocks, 8x8x16-in.; 8-in. Wall:	
90 blocks at 5 ct	$ 4.50
2 sacks cement at 30 ct	0.60
Sand	0.10
Total materials	$ 5.20
Delivering, 2 hr. at 32 ct	0.64
Building, 14 hr. at 32 ct	4.48
Total labor	$ 5.12
Grand total	10.32

Accelerating the Hardening of Concrete.—An investigation recently conducted by the Bureau of Standards, Washington, D. C., disclosed the fact that the use of a 4 per cent solution of calcium chloride in place of the mixing water would materially accelerate the hardening of concrete. This acceleration varies somewhat with different cements. With some cements in 1:2:4 concrete it was found that the strength increased 100 per cent in 24 and 48 hours. This, it is believed, is due to the more complete hydration of the silicates and aluminates for it was found they were more completely hydrated when the calcium chloride was used. Its use increases the cost of concrete 12 to 15 ct. per cubic yard. Calcium chloride should not be used in reinforced concrete where site is to be exposed to electrolysis. This investigation will be continued in order to determine the ultimate value of calcium chloride when used in concrete.

Grouted Stone Track Foundation.—Foundation for street railway track in Baltimore is being constructed by grouting ballast in place. The ballast used is 1½ to 2½-in. broken stone. This is placed and tamped under the ties in the usual manner. Then a 1:2 cement-sand grout mixed to the consistency of cream is poured over the ballast until all voids are filled. A machine grout mixer traveling alongside the tracks is used, the discharge being by chute directly onto the ballast. An excellent concrete is said to be obtained. The grouting costs about 52 ct. per lineal foot of track.

Cost of Cement Bags.—Precise figures of value of the cost to users of cement sacks are given by Mr. L. C. Wason. They are based on exact records on several jobs for which 403,576 bags of cement were received and 390,458 cement bags were returned and credited. The figures are:

Bags lost or worthless, 3,586 at 7½ ct	$ 268.50
Bags lost or worthless, 9,538 at 10 ct	953.80
Return freight	725.06
Labor, shaking and bundling	1,590.00
Wire, marlin, etc	66.50
Total loss and expense	$3,603.86

There being 100,894 bbl. of cement the cost of bags to user per barrel was 3.6 ct.

Improved Target for Determining Azimuth.—The illustraction shows a target for determining azimuth, which was employed in a topographical survey of Fort Sill Military Reservation in Oklahoma. It is described in "Professional Memoirs" by Lieut. D. H. Connolly, Corps of Engineers, as follows: The only thing worthy of mention was the target. Two kinds were tried. One was the usual book method of letting the light shine through a hole in a piece of tin, making the hole of such size that the mark looked about the same size as the star. The target which gave better results is shown by the sketch. This target was plumbed over the copper plug in the monument. In sighting on the mark, the opaque design on the target was bisected by the cross-hairs of the theodolite. This target was better than the hole in the tin, because it made a large flare which helped in picking up the mark quickly. As time is an important element in this kind of observation, and the base line made quite an angle with the meridian (about 80 degrees), this ease in picking up the mark was a big advantage. The target was illuminated with two burners attached to one of the small acetylene lamps furnished engineer troops for use in the drafting tent. One or two more burners would have been better, as two burners did not light it quite enough for the cross-hairs to stand out against it. It was necessary to illuminate them a little. Azimuth was determined from Polaris.

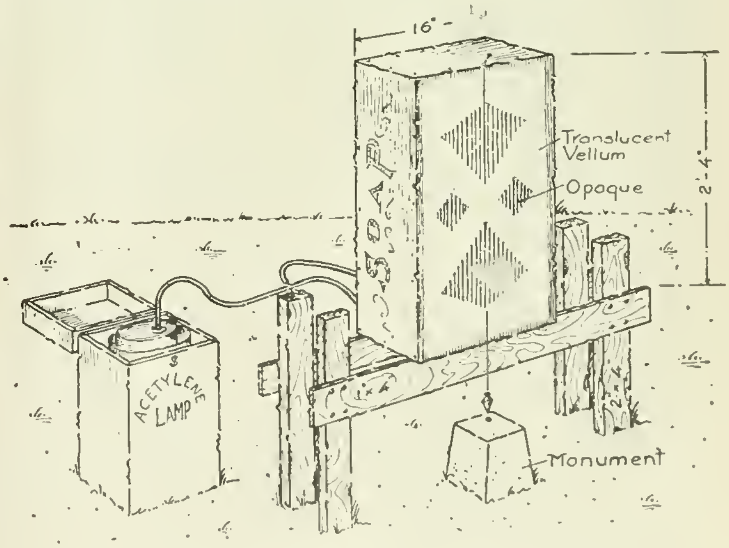


Fig. 2—Target for Determining Azimuth on Polaris.

DESIGN AND CONSTRUCTION OF THE SEWAGE TREATMENT PLANT AT PANA, ILL.—TRICKLING FILTER A FEATURE.*

By A. C. Stanfield, City Engineer, Pana, Ill.

The city of Pana, Illinois, with a population of about 7,000, has just completed a plant for treating its sewage. Its sewerage system consists of about nine miles of symmetrical sewers ranging in size from 8 to 24 in. and serves two districts the combined area of which is approximately 400 acres. The sewers were laid in 1906 and 1907 and the outlet, a 24-in. tile sewer, was carried south to Coal Creek, a small dry weather stream about three-fourths of a mile south of the city.

During the last three or four years complaints have been made and suits filed against the city by farmers along the stream and below the outlet for contaminating the stream water which was used by them for stock; some of these suits were successful and damages have been collected from the city. On Jan. 1, 1915, the city began proceedings to construct a sewage treating plant and after investigating a number of different types of plants decided upon the trickling filter preceded and followed by sedimentation. Figures 1-4 are views of the plant.

The sewage is purely domestic and measurements made during a normal day flow showed a rate varying from 71,000 gal. minimum to 205,000 gal. maximum or an average rate of 133,000 gal. taken from 8 readings.

Financing the Project.—The city, like many others of its size in the State, was so limited in its bonding capacity that with its present indebtedness it could not raise sufficient funds to build the plant by general taxation, consequently the matter was referred to the Board of Local Improvements and the funds were raised by special assessment which covered a district including the two sewer districts and about 15 acres of land lying outside these districts. The assessment amounting to an average of $23.40 for an average 60-ft. lot was divided into five annual installments. It was confirmed by the county court and the contract for the construction of the plant was awarded to Messrs. Sell & Kollar of Pana on April 30, 1915.

Owing to the topography of the city only the district included can be served by the plant and the outlet sewer; however, it covers the business portion and the better residence sections of the city having an estimated population of 3,300 people, 2,200 of which are using the sewer. Considering the ordinary growth of Illinois cities of this class it was assumed that a plant designed to provide for a population of 4,000 persons would provide ample capacity for the district, and it is considered to have such capacity based upon a proportionate increase of the present flow.

The main outlet sewer is a 24-in. pipe and in its lower 600 ft. of length has a fall of about 15 ft., and in order to make this available for the operation of a gravity plant an intercepting sewer was laid at a higher grade making it possible to bring the sewage to the plant at an elevation of 13.50 ft. above the final outlet.

The plant consists of a settling tank of the double compartment type, automatic dosing tanks, a trickling filter, a secondary or humus tank and a sludge drying bed. A line drawing of the north elevation of the plant is shown in Fig. 5, which also shows the hydraulic elements of the plant.

Primary Settling Tank.—The tank consists of a settling channel and a sludge chamber, the former being so arranged that the sewage may enter either end thereof, each entrance being furnished with a small grit chamber and a valve by which the flow may be controlled. A central trough is supported by the division wall between the settling channel and sludge chamber and connects with outlet weirs at the ends of the channel and allows the sewage to flow into five small dosing tanks, supported on the walls over the sludge chamber, from which tanks it is discharged through a system of distributing troughs over the trickling filter. The principal sections and details of the primary settling tank are shown in Fig. 6.

The settling tank is 22 ft. wide by 90 ft. long and 21 ft. deep, inside dimensions. Its sludge chamber is divided into three compartments by two cross walls for the purpose of strengthening the side walls and supporting the interior walls with the longitudinal trough system, dosing tanks, etc., and is provided with cast iron sludge pipes placed through the center with branch openings for drawing off the sludge by gravity from the different sections of the chamber and discharging it upon the sludge drying

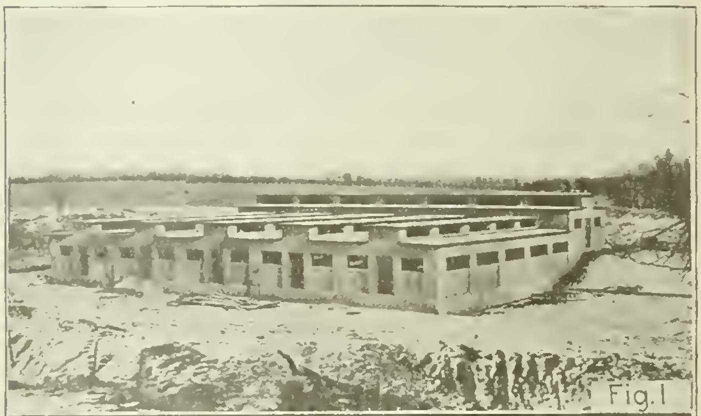


Fig.1

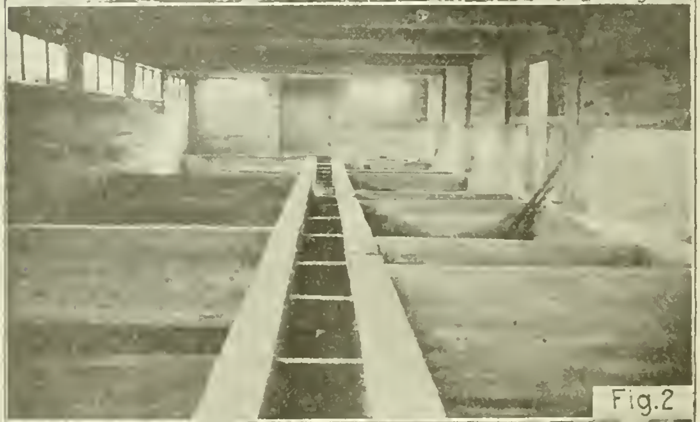


Fig.2

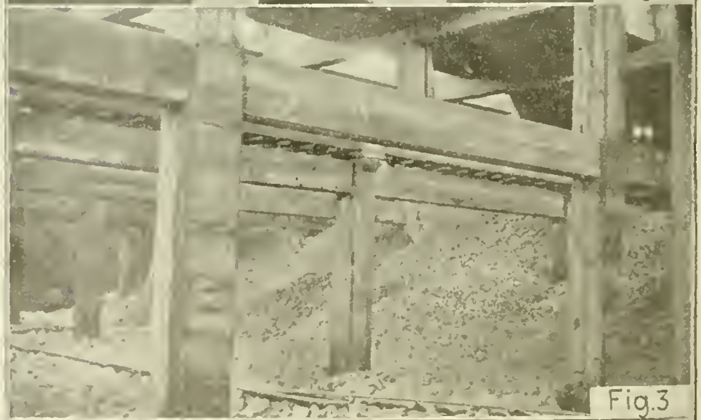


Fig.3

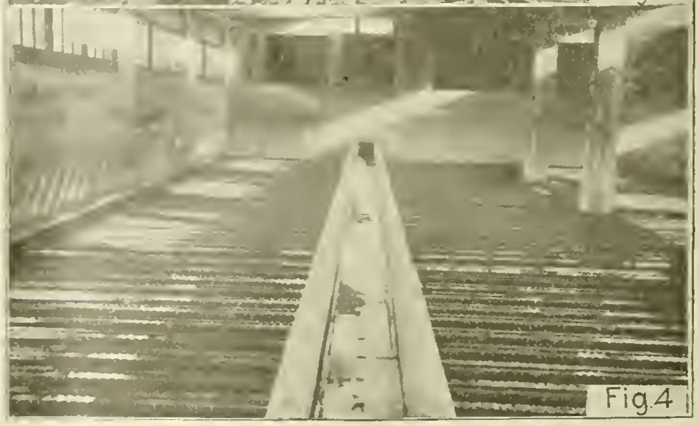


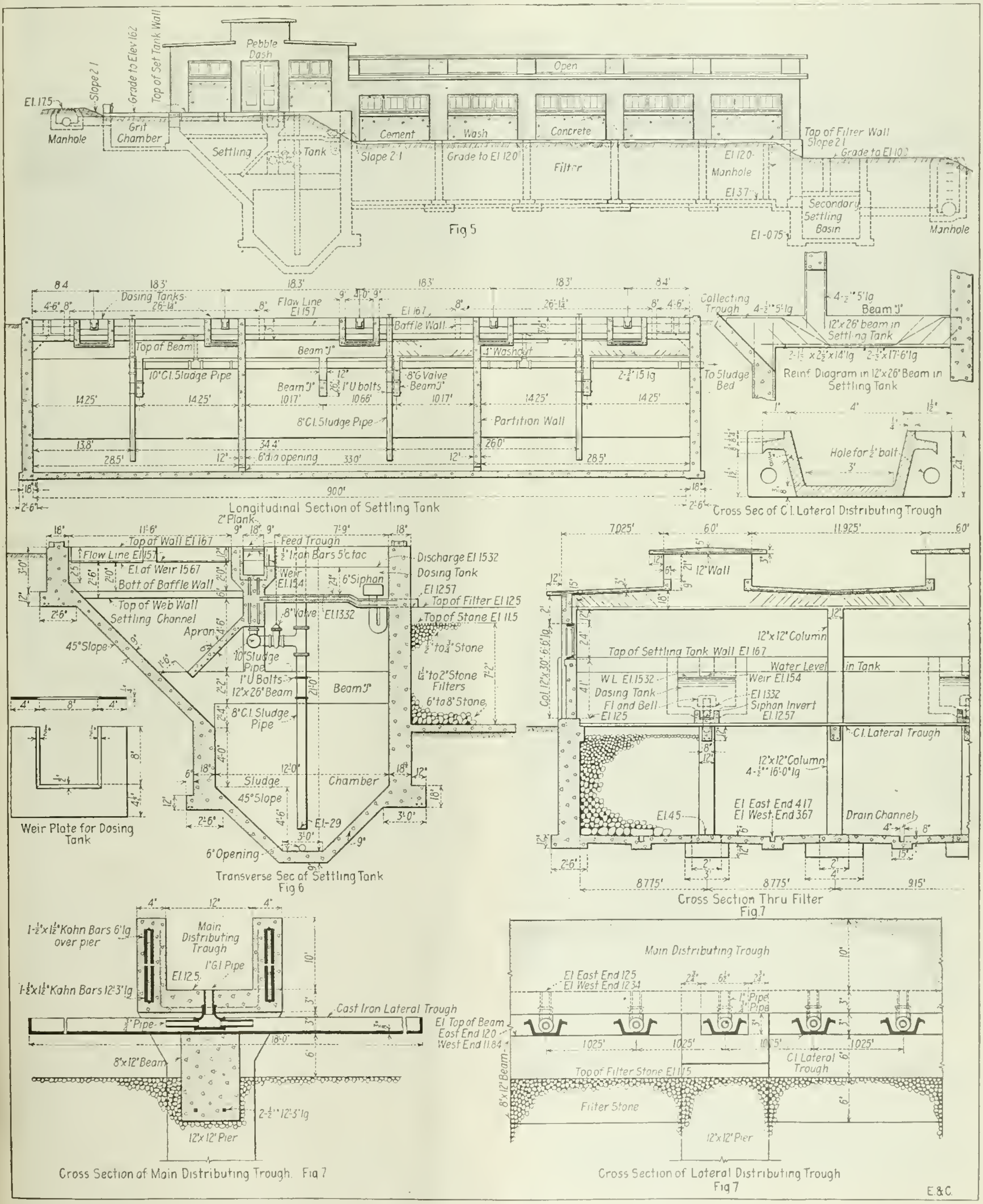
Fig.4

VIEWS OF NEW SEWAGE TREATMENT PLANT AT PANA, ILL. Fig. 1. Exterior View of Plant. Fig. 2. Interior of Primary Settling Tank. Figs. 3 and 4. Interior Views of Trickling Filter Beds.

---

*Paper before joint annual convention of Illinois Society of Engineers and Surveyors and Illinois Section of American Water Works Association.

bed outside. The main trough is covered with plank to form a walk and the dosing tanks are equipped with 5-in. Miller automatic siphons discharging at an operating depth of 24 in. The settling channel is provided with baffles and is designed for a retention period of from one to two hours when the rate of flow is from 200,000 to 300,000 gal. per day with a velocity of from 1 to 2 ft. per minute. The sludge chamber has a capacity of 19,000 cu. ft. or 4.75 cu. ft. per capita. The dosing tanks have a capacity of 500 gal. each and discharge independent of each other delivering approximately 500 gal. of water to the filter, and with a normal flow or 200,000 gal. per day will discharge once in 18 minutes including the two minutes required to discharge.



SOME DESIGN DETAILS OF THE SEWAGE TREATMENT PLANT AT PANA, ILL.

Fig. 5—North Elevation, Showing Hydraulic Elements, of the Plant. Fig. 6—Principal Sections and Details of the Primary Settling Tank. Fig. 7—Details of the Trickling Filter.

Trickling Filter.—The trickling filter is 60 ft. wide by 90 ft. long by 7 ft. deep. It is surrounded by concrete walls and rests upon a concrete floor having corrugations thereon to form drain channels. The channels are covered by large stone to prevent the entrance of small stone and discharge into a larger drain which has an outlet into the secondary settling basin. On the floor of the filter is placed a layer of stone ranging in size from 6 to 8 in. set on edge by hand, and on top of this layer is 5½ ft. of 1¼ to 2 in. stone and on top of this a final layer of ½ to 1 in. stone. Details of the filter are shown in Fig. 7.

The distributing system consists of five main concrete troughs running from the dosing tanks across the filter, each trough supplying one-fifth of the filter or a section 18 ft. by 90 ft. These troughs are reinforced and supported upon concrete piers resting on footings beneath the floor of the filter and each trough is provided with 56 one-inch feed pipes in its bottom spaced equi-distant along its center line. Each pipe has a horizontal tee on the bottom providing two openings into the distributing trough beneath. Immediately below the feed pipe and running at right angles therewith, are placed cast iron distributing troughs. These troughs are 2 in. deep by 4 in. wide at the top and 3-in. wide at the bottom. On the outside of each wall of the trough placed ½ in. below the top edges thereof projects a ledge having a scalloped edge from which the water drops to the stone below. The top edges of the sides are notched with triangular notches ¼ in. deep and spaced 1⅓ in. apart. These troughs are about 6 in. apart and rest upon concrete beams supported by columns at such a height that the water drops about 8 in. from the trough to the stone.

The openings to the feed pipes in the bottom of the main troughs were formed of 1-in. galvanized pipe but these were found to be too large and they were reduced with lead bushings to 9/16 in. which seems to give a more uniform distribution throughout the whole length of the trough. The total area of the filter less deductions for columns taken at 5,360 sq. ft., gives approximately 1⅓ sq. ft. per capita based on 4,000 population to be served. An interior view of the filter is shown in Fig. 4.

The secondary tank is 8 ft. by 40 ft. inside and with a depth of 4.5 ft. of sewage the capacity is 10,800 gal. and a retention period of more than one-half hour.

The sludge bed is 30 ft. by 50 ft. surrounded by a concrete curb and consists of a layer of sharp, coarse, sand 18 in. in depth underdrained by lines of 4-in. farm tile laid 5 ft. apart.

Flexibility of Operation.—The plant is designed with as much flexibility as possible. It is provided with valves to pass the entire sewage flow around the plant, or to conduct it into either end of the settling channel from which it passes to the feed trough, and from this trough it may be passed out to the sewer thus using only the grit chambers and the settling tank, or it may be passed into any or all of the five dosing tanks thus making it possible to use any or all of the five sections of the filter bed. From this bed it may be passed either to the outlet sewer or through the secondary settling basin thence to the outlet.

Plant Housing.—The tank and filter are entirely enclosed by a reinforced concrete building 86.5 ft. by 93 ft. designed to furnish good light and ventilation, protect the filter from low temperatures, and from debris being deposited upon it. The structure is fireproof except the doors and windows. All windows are protected by heavy wire screens. The outer walls have a pebble dash finish, and the roof slabs have a sidewalk finish painted with weatherwear paint.

The Kahn system of reinforcing was used throughout and the cast iron distributing troughs were furnished by the Paris Machine and Foundry Co., Paris, Ill.

The plant, a view of which is shown in Fig. 5, is interesting as it is, so far as the writer knows, the first of its kind in this section of the country. It is similar in some respects to the plant of the Allis-Chalmers Co. at Milwaukee, Wisconsin, where our committee visited a trickling filter which had been operating continuously for 12 years at a capacity rate much higher than in this plant. The plant has been operated only a few days, and while it has not yet attained proper working conditions, a very satisfactory effluent is being discharged into the creek. We expect the cost of operation to be less than $100 per year.

The plant including land, legal fees, engineering and supervision has cost $31,000, or an average of $7.75 per capita.

The W. S. Shields Co., Chicago, Ill., were designing and consulting engineers and the writer had charge of construction.

A New Engineering Publication—The Monad.—The Monad, the official publication of the American Association of Engineers, has recently made its appearance. The publicatiton is to be devoted to the commercial interests of all technical engineers and their profession. The first issue contains information relating to the American Association of Engineers, together with a full report on the recent convention of the association in Chicago. The publication is in the form of a booklet, 5x8 in., and is published from the headquarters of the American Association of Engineers at 29 South La Salle St., Chicago, Ill.

RECLAIMING STONE FROM OLD MACADAM FOR CONCRETE BASE.

Contributed by Stanley E. Bates, Assoc. Mem. W. S. E.

One of the problems attending the replacing of an old macadam street with a higher type of pavement laid on a concrete base, is how to reclaim the old stone for use as aggregate in the concrete. This problem is a particularly important one in Chicago, Ill., where, roughly speaking, two and one-half million square yards of asphalt, asphaltic concrete, wood, brick and stone block are laid every year, more than 10 per cent of which replaces existing macadam. A quarter of a million square yards of macadam 5 in. thick means nearly 35,000 cu. yd. of stone.

The use of the old stone forms quite a considerable item in the contractors' bids, proven by the fact that bids for sheet asphalt pavements run from 7 to 15 ct. per square yard lower where there is old stone available than where the old surface of the street to be paved is of earth. Consequently, economical methods of removing and cleaning the old macadam are of importance.

About two years ago a member of a large Chicago contracting firm, the American Asphalt Paving Co., invented a machine adapted to this work. It is called a macadam screening cart and is manufactured by the Briggs Chicago Co., Chicago, Ill. The American Asphalt Paving Co. now has a large number of these screeners in use, other methods of reclaiming stone being used only under rare circumstances.

A good example of the use of the screens was found last fall in the paving of the Yale and Stewart Ave. Systems, an 83,400-yd. job of sheet asphalt and asphaltic concrete. The contract was not let until Oct. 3, 1915, which made it necessary to handle this large job very expeditiously. Six grading gangs, each with about 35 men and 25 teams, were employed on the work, each using six of the macadam screens or "peanut roasters" as they are sometimes called on the job.

As noted in the illustration, the screener is simple in both principle and construction, consisting merely of a cylindrical screen mounted on a pair of wheels drawn by two horses. The screening drum is made of No. 3 gage mesh with wires in each direction 1 in. apart in the clear, reinforced on the inside by two cylindrical steel bands, and on the outside by eight transverse steel bars. It is rotated by being attached to one of the wheels by six angular legs riveted to the rim of the drive wheel. The drum heads are of sheet steel. The dimensions of the screening drum are: diameter, 40 in.; length, 45¼ in. A loading door, 17 in. wide and extending the full length of the drum, is swung on hinges and fitted with a releasing liner operated by hand. The wheels are 66 in. in diameter with 6 in. tires and the tread is 4 ft., 8½ in. The cart is built of steel throughout and weighs about 1,600 lb.

In operation on the Yale Ave. work, the old macadam, after being broken up with a rooter plow, was loaded into the drum with forks. Four or five men made up the shovelling crew for one screener. The drum holds about $1\frac{1}{3}$ cu. yd. of material but it has been found that the best results obtain when it is not more than two-thirds filled.

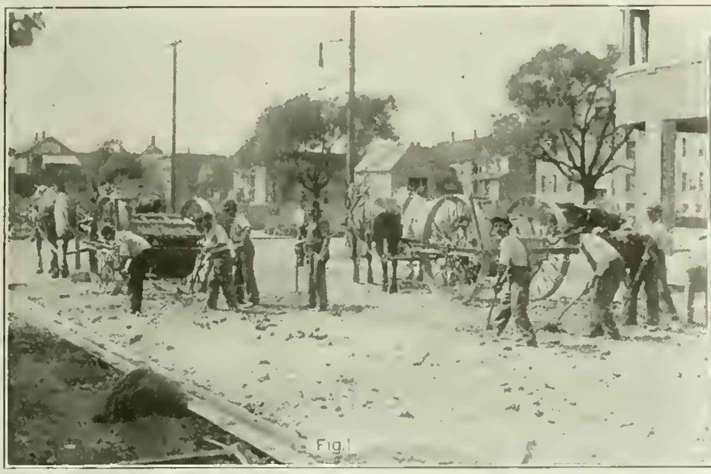


Fig. 1—Loading Screen With Macadam.

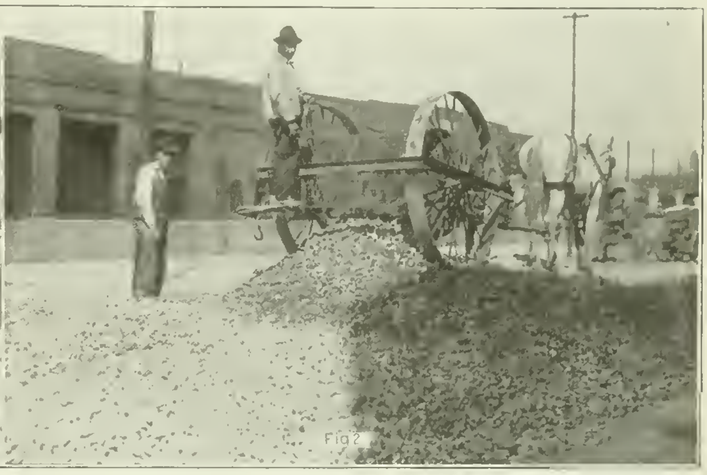


Fig. 2—Discharging Screen on Stone Pile.

After a cart was loaded in this manner with a mixture of stone and fine material, it was driven to a stone storage pile, usually located at the end of an intersecting street. The work was so laid out that each screener had to travel at least one long city block from the point of excavation to the storage pile, in order that all of the dirt and fine material would sift out through the mesh and leave the stone clean.

The screeners were driven up onto the storage pile, as shown in the illustration, and dumped. Two or three men were located at each pile to assist in dumping the screeners and also to sort out and break up all of the large stones with mauls. The specifications called for all stone to be less than 3 in. in diameter while in the old macadam many stones 4 and 5 in. in diameter were found.

Many of the old macadam streets had received annual treatments of heavy asphaltic oil for several years. The oil had cemented a layer of the upper stones together, forming, in some places, a mat of considerable thickness on the surface.

Where the mat was not too thick it would break up in the screeners and the oil coated stones would not form a large percentage of the entire reclaimed material; at least, not so large as to render the stone unfit for use in the concrete base. On a few of the streets, however, where the bituminous mat was of exceptional thickness it was removed by hand to the sides of the street and later, hauled away to the dump. The illustrations show a thick mat of stone, dirt and oil which had to be removed in such a manner. In places it was more than 2 in. thick and could hardly be broken up except by means of a pick.

After all of the stone had been reclaimed there remained considerable material to be hauled away to the dump, consisting of the material passing through the mesh of the screens and earth excavation beneath the old macadam. Necessarily there was quite a percentage of good stone, less than an inch in diameter, in this waste material. The stone was made use of, to as great an extent as possible, in the following manner:

The mixture of small stone and dirt from the screeners ordinarily found its way a little to one side of the center of the roadway, being the route taken by the screeners on the trip to the storage pile. After all of the macadam had been taken up, dump wagons followed to receive all of the waste material. In removing this and leveling and shaping up the subgrade, as much stone was left as possible, and was used in crowning up the surface, thereby providing an extra good surface on which to lay the concrete pavement base.

Two rollers were used in connection with the six grading gangs. One went in on a street in advance of the shovelers and spiked up the surface, also plowing it up with a rooter plow. The second roller was used to roll the finished subgrade, in advance of the concreting crew. The usual make-up of each grading gang was as follows: 1 foreman, 1 timekeeper, 26 laborers, 5 finishers, 1 water boy and 1 watchman, or a total of 35 men. Added to this there were the 25 teams each with a teamster, and the rollers and roller operators noted above.

Grading began on Oct. 9, 1916, and was finished on November 13, a total of 36 days elapsing from the beginning to the end of the work. However, as the men were at work only two Sundays, and some of the crews were laid off before Nov. 13, 32 full days would be a liberal estimate of the time required for the six gangs to complete the work.

With a total of 83,400 sq. yd. of macadam removed, the amount excavated in one day averaged 2,606 sq. yd., or 434 sq. yd. per day for each gang of 35 men. The macadam averaged about 5 in. thick, making about 11,600 cu. yd. of stone reclaimed; 360 cu. yd. per day; 60 cu. yd. per gang per day. In addition, bringing the subgrade to the proper elevation necessitated removing all the way

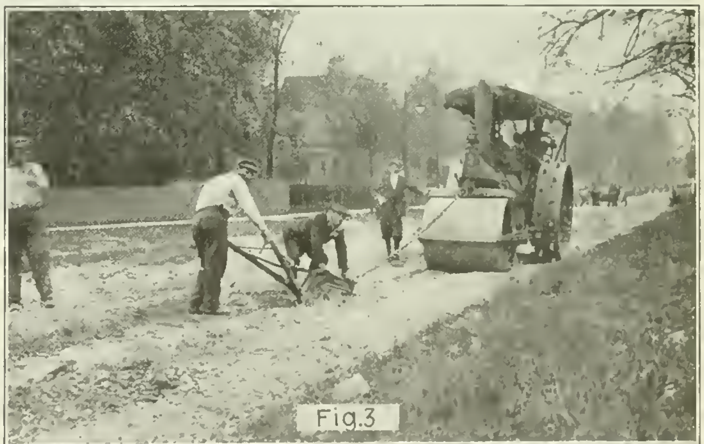


Fig.3

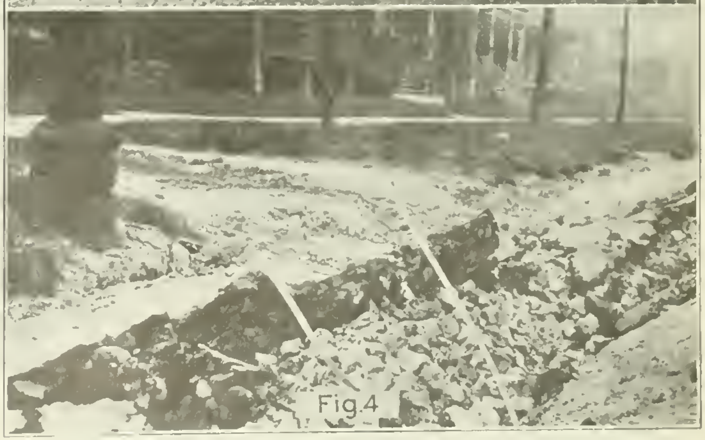


Fig.4

Fig. 3—Rooting Up Old Macadam.
Fig. 4—Mat of Oil Bound Macadam.

from 1 in. to 18 in. of earth underlying the macadam. This probably averaged 4 in. in thickness, in round numbers, 9,300 cu. yd.; 300 cu. yd. per day; 50 cu. yd. per gang per day. Total earth and macadam excavation, 9 in. thick, 20,900 cu. yd.; 660 cu. yd. per day; 110 cu. yd. per gang per day.

Those in charge of the engineering part of the work were John B. Hittle, Chief Engineer of Streets, and G. E. Bronson, Division Engineer of the Board of Local Improvements, Chicago. E. G. Schwendenan is Superintendent of Construction of the American Asphalt Paving Co.

A CALL TO A CONFERENCE ON CO-OPERATION.

An invitation is being issued to all engineering organizations to send delegates to a conference on engineering co-operation to be held on Thursday and Friday, April 13 and 14, in the rooms of the Western Society of Engineers, 1735 Monadnock Block, Chicago, Illinois.

The response to the letter sent out in the name of the Committee on Engineering Co-operation on Sept. 1, 1915, has been productive of so many suggestions and general interest in co-operation is now so strong that the time seems to have arrived when the more important topics should be discussed by professional men from various parts of the country. The following items among others may be considered:

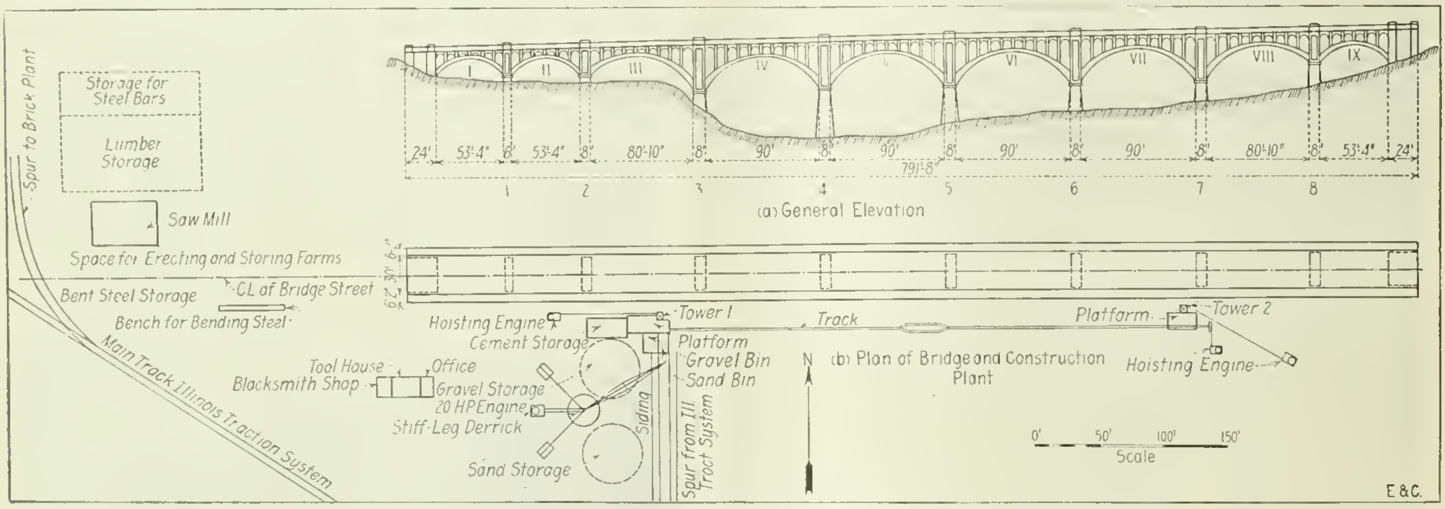


Fig. 1—General Plan and Elevation of Reinforced Concrete Viaduct at Danville, Ill., and Layout of Construction Plant.

1. Co-operation among engineering organizations. Is it desirable? In what way is it practicable?
2. Benefits of co-operation in securing greater efficiency in the larger matters of concern to the individual engineer and to the profession.
3. Methods of co-operation now in practice in various localities; results attained in Philadelphia, St. Louis, St. Paul and other places.
4. Various kinds of engineering societies and committees and the relative efficiency of their operations.
5. Relation of the specialized or exclusive national engineering societies to their local sections or branches and to the more inclusive local engineering society or club.
6. Result of co-operation in securing wider diffusion of knowledge on engineering subjects, as illustrated at Cleveland and elsewhere.
7. The engineering profession as a whole in its present condition as regards public esteem.
8. Reasons for decline in attendance at engineering colleges. Is it indicative of healthful conditions or of proper methods of education?
9. Employment; methods and results as practiced by various engineering societies; an exchange of ideas.
10. Legislative activity, proper limits to be set, dangers to be avoided and needs of more systematic and better directed efforts.

The above lines of discussion are by no means intended to limit the conferences, but on the contrary indicate certain starting points. It is expected that each of these will be presented by some man fully informed on the subject and will afford an opportunity for exchange of ideas and experiences.

The sessions will begin at 9 a. m. on Thursday, April 13, and will be continued by subcommittees or in general conferences until some concensus of opinion has been reached. It is hoped to arrive at an agreement on some of the fundamentals and to stimulate activity toward the accomplishment of definite results along lines which are now being so broadly discussed. F. H. NEWELL,

Professor of Civil Engineering, University of Illinois.
Urbana, Ill., Jan. 26, 1916.

METHODS AND EQUIPMENT USED IN CONSTRUCTING A REINFORCED CONCRETE VIADUCT AT DANVILLE, ILL.

Contributed by N. B. Garver, Associate in Civil Engineering, University of Illinois.

The Bridge Street viaduct, which was recently completed across the North Fork of the Vermillion River, at Danville, Ill., is a reinforced concrete structure of the arched rib type, with spandrel posts and a girder-and-slab floor. It has a total length of 791 ft. 8 in. and provides a 30-ft. roadway and two 5-ft. sidewalks. The viaduct consists of nine arch spans of the following lengths: three 53-ft. 4-in. spans, two 80-ft. 10-in. spans, and four 90-ft. spans. The maximum height from stream bed to roadway is about 70 ft. The abutments are of the U type, with wings 24 ft. long. The design features of the structure are indicated in the general elevation shown in Fig. 1 (a). The viaduct contains about 5,000 cu. yd. of concrete and about 225 tons of reinforcing steel. The method used in handling materials, from the car to their final position in the bridge, is particularly worthy of note, and this feature will be described in detail.

Construction Plant.—The layout of the equipment is shown in Fig. 1 (b).

The saw mill is equipped with a band saw, a rip saw, a swinging saw and a boring machine. The power is furnished by a 10-hp. gasoline engine. All forms were cut in the mill and assembled in the open space adjacent to it.

A stiff-leg derrick (see Fig. 2), equipped with bull-wheel and an 85-ft. boom, was used to unload all materials except lumber and steel bars, which were unloaded by hand from cars on the spur track near the storage yards. A 20-hp. steam engine furnished power for the derrick.

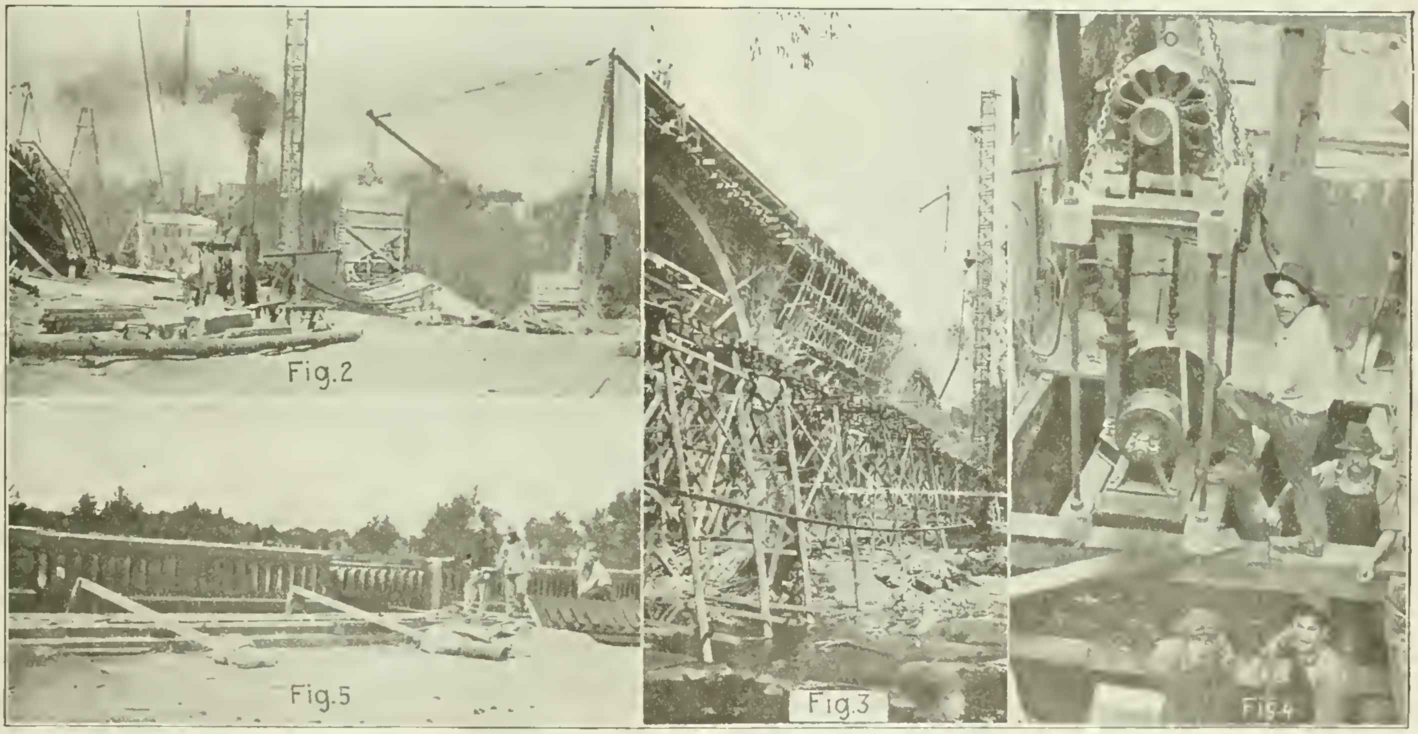
The wet concrete was transferred from the mixer to the forms by means of an Insly spouting system. Tower No. 1, which was 158 ft. high, was utilized for pouring the west five spans, while tower No. 2 had a height of 172 ft. and was used to pour the remainder of the concrete. The position of these towers is shown in Fig. 1 (b). A 30-hp. steam engine was used to operate the skip. The towers (see Figs. 2 and 3) were constructed of 6x6-in. posts, braced in 7-ft. bents by 2x10-in. struts and 2x6-in. diagonals. These members were bolted together with ⅝-in. bolts. The spouting systems were supported by 1-in. steel wire cables attached to the towers. Three sets of ⅜-in. cables were used to guy each tower, each set consisting of four cables. The tower hoists were operated with ½-in. cables.

Elevated sand and gravel bins, with capacities of 45 and 60 cu. yd., respectively, were built. Owl cement was used, the cement being stored in a corrugated iron building located near tower No. 1.

The concrete was mixed with a ½-cu. yd. Smith mixer, water being supplied from the city mains.

Pumping was required only in the excavations near the stream. This was done with a 4-in. centrifugal pump driven by a 10-hp. electric motor. The motor and pump were mounted on a frame (see Fig. 4) and were swung over the excavation by means of a chain hoist. By this arrangement it was possible to place the pump at any desired elevation.

Gin poles, set on the falsework, were used to hoist the reinforcing steel to place in the arch ribs. This reinforcement consists of four angles laced to form a box section.



CONSTRUCTION VIEWS OF REINFORCED CONCRETE VIADUCT AT DANVILLE, ILL.
Fig. 2—Derrick and Engine Used in Unloading Materials from Cars on Spur Track. Fig. 3—Falsework and Elevated Construction Track Along Viaduct. Fig. 4—Motor and Pump Mounted on Frame and Swung Into Excavation Pit. Fig. 5—View of Section of Concrete Railing and of Forms for Same.

Methods of Handling Materials.—The form lumber and steel bars were unloaded from the cars by hand and were stored in the yards adjacent to the mill. All bending of bars was done on the work by hand.

The sand and gravel were unloaded from cars set on the spur track adjacent to the bins and storage spaces. The stiff-leg derrick was equipped with a ¾-cu. yd. grab bucket, and the gravel or sand was placed either in the bin or storage space, as desired.

The reinforcing steel for the arch ribs was also unloaded with the aid of the derrick. Those pieces which were to be used on the east end of the structure were loaded directly on wagons and hauled to that side of the river.

In mixing the concrete the proper quantities of sand and gravel were drawn from the bins into a hopper by means of spouts, after which the cement was added. The whole was then spouted from the hopper into the mixer which was located under the platforms shown in Fig. 1. With this arrangement the capacity of the mixer was about one batch per minute. With the exception of the cement no materials were handled by hand.

The concrete for the railings was mixed by hand, since this work lagged behind the other parts of the construction. Figure 5 shows some of the railing forms and also some sections of the finished railing.

Order of Construction.—All piers and abutments rest on a thick bed of shale, which lies a short distance beneath the surface of the ground. No difficulties were encountered in excavating for and in concreting the foundations.

Construction work began at the west end of the structure and proceeded eastward. The west abutment was first built, then piers Nos. 1 and 2. The falsework and forms were then constructed for the arch ribs of the first span and the concrete then poured. From that time forward the general scheme of construction was to have the falsework and forms for the arch ribs in one span, together with the spandrel posts and deck of the preceding span, under way at the same time. The arch ribs were poured one day and the deck for the preceding span the following day.

When span No. 5 was reached, both the arch ribs and deck were poured. The mixer and hoisting engine were then moved from tower No. 1 to tower No. 2. A 2-ft. gage track had been constructed on a trestle, as shown in Figs. 1 and 3, with a down grade toward tower No. 2. The materials were dumped in the hopper at tower No. 1, as formerly, but from there they were placed in cars on the track and transported to the mixer at tower No. 2. There were two cars, each with a capacity of one batch of concrete. These cars were fastened to a cable, as it was first thought that the loaded car going down the incline would draw the empty car back. This arrangement did not prove to be satisfactory, however, so a small steam hoisting engine was used to operate the cable with the cars attached.

There were no delays in loading and unloading the cars, since each car was loaded from a hopper at the upper end and unloaded into a hopper at the lower end.

Personnel.—The contractor was J. J. Jobst, of Peoria, Ill.; the contractor's superintendent was E. C. Miller; and the contractor's engineer, F. C. Thorpe. J. B. Marsh, of Des Moines, Iowa, was the designer, and W. H. Martin is city engineer of Danville. The writer was consulting engineer for the city of Danville.

CONCERNING A NEW ORGANIZATION OF ENGINEERS.

To the Editors: In an editorial in your issue of Jan. 12, 1916, you ask engineers to reply to the following two questions:

1. Is there present need for a separate organization whose principal object shall be to secure wider public recognition of the engineering profession and to promote the interests of engineers?

2. Can you suggest a plan of organization to which you would be willing to give active support?

In reply to these questions I submit the following:

1. There is little use for such an organization. The colleges are turning out men faster than they can be absorbed. The boys enter the technical courses in ignorance and good faith. One western educator who carries a speech on a hair trigger on most any subject from astronomy to zoology informed a good roads convention last fall that there "was a demand for engineers for railroad work." What do you think of that?

The rising tide of engineers must be left to nature to work out a solution. The West is full of unemployed engineers, yet next June another batch is due from the mixers. Has any technical school investigated the multitudes that took the exam for valuation of railways? There were about 100 applicants for each job. To sum up question 1: The situation looks hopeless to me.

2. A national organization that will be in reality an Engineers' Employment Bureau is our need; head office, Chicago; branches, New York, New Orleans and other cities as need arises.

Dues, two dollars per year. Membership of two grades, Associate and Member: Associate Members, five years' experience in engineering work, college degree to count two years; Members, ten years' experince.

When a man is out of work he is to notify the nearest secretary, or all secretaries if he so desires, and state his wants, his experience being on file. If engineers would only hire through the association or association members it would be a success.

The railroads have ruined civil engineering by paying the very lowest wages and requiring Sunday and all overtime labor gratis. The government, states and counties have all conformed to the cheap wage scale set by the railroads. Engineers (not enginemen, by any means) on western railroads are receiving the same rate of pay as in the eighties. In the meantime the cost of living has doubled. The best thing an engineer can do is turn farmer or such the first chance he gets. Some have had luck contracting. The two questions are pertinent and pressing, but the answer of one who has been in the field twenty years has to be "let 'em press."

Very truly yours, F. W. Harris.

Renton, Wash., Jan. 27, 1916.

OVERCOMING TROUBLE FROM PRESENCE OF LARVAE IN CHAMPAIGN-URBANA WATER SUPPLY.*

By F. C. Amsbary, Manager Champaign-Urbana, Ill., Water Company.

After building and placing in successful operation our plant for the removal of iron from our well water supply, we were congratulating ourselves on finally succeeding in removing the iron when we began to get complaints from our customers that small red worms had been found in the water. At first we thought this an error, but when a customer brought to our office a bottle of water containing perhaps a dozen live, squirming, red worms we immediately began investigation.

I took the bottle containing the worms to Dr. Stephen A. Forbes, State Entomologist, who immediately classified them as larvae. He assured me they were entirely harmless; in fact, when found in water supplies it indicated the water to be of high purity. I was of course considerably relieved and when the next customer complained I assured him, or tried to, that he should not be alarmed; that I had the authority of Dr. Forbes that the larvae were harmless and that their presence in the water proved it to be of unusual purity. I was disappointed in the man. He said: "Dr. Forbes and you be darned. If you expect me to buy water full of worms and pay for it, I will refer the matter to the Mayor and City Council, the State Public Utilities Commission, the Board of Health and the Poundmaster."

Several other interviews with irate, worm-hating customers convinced me something would have to be done; somehow Champaign and Urbana water consumers could not reconcile the theory of pure water with the fact of a worm content. I would say that in discussing the matter with our patrons, I used the word larvae; the word seemed less vulgar than worm, but in every case the patron used the word worm—in fact one man was impolite enough to call them small snakes.

Somewhat discouraged, I again called on Dr. Forbes and asked him what could be done to be rid of the pests. It was suggested that fish or frogs be put in the reservoir, that they would feed upon the larvae, and a system of screens could be installed to prevent the fish or frogs from finding their way into the water pitchers about town.

This did not appeal to us, for we did not care to turn our reservoirs into fish or frog ponds. Dr. Forbes informed us that a period of six weeks was necessary for the evolution of the eggs to the winged midge. We then decided to clean our filtered water basin once a month and break up the breeding ground of the larvae.

I asked Dr. Forbes to write an article for the local newspaper explaining the matter from a scientific standpoint which would tend to allay the fears of our patrons, who were already blaming us for all the sickness in town, until we had time to carry out our plans.

This he did. Dr. Forbes' article on this subject, published in the Urbana "Courier," follows:

DR. FORBES DESCRIBES THE LARVAE.

Nearly every one must have noticed in spring and fall swarms of small midges stationary in the air at a little distance above the ground, especially in the neighborhood of ponds of water courses, every member of the company flying actively around and about and in and out, but the swarm as a whole curiously motionless or perhaps rising and falling slowly with the wind. These little midges—often called harlequin flies in England—are really executing an intricate aerial dance, each swarm being a dancing party of males, into which an excited female will every once in a while make a sudden dash, seizing upon an unreluctant male and flying away with him for a mate. Later she dips down to the surface of the stream or pool and lays a rope of delicate eggs held together in strings by a gelatinous envelope which immediately swells up when wet into an abundant, transparent mucilage, within which the eggs are held imbedded.

From these transparent larvae presently hatch and sink to the bottom, where they lie buried in the mud and sediment, feeding on particles of vegetation and other organic debris which it contains. They are so abundant in our natural waters that they are an important element in the food of nearly all our fishes, and I have myself taken them in quantity from the stomachs of black bass, white bass, perch, sunfish, crappie, minnows, suckers, buffalo fish, dogfish, spoonbills etc.—more than sixty species of Illinois fishes in all which I know to feed upon them. We have immense collections of these little larvae from all kinds of Illinois waters; and a specialist has been at work for months at my laboratory unraveling their classification, describing new species, rearing larvae to the winged midge, and helping to make us acquainted with this important complex group. Some kinds of these larvae are colorless and nearly transparent, others are white, and a good many are red, from which fact they have received the common name of "blood worms." They are not worms, however, but insect larvae, as I have just explained.

They are entirely harmless in every stage, the larvae helping to keep the water clean by devouring substances which might otherwise decay, and the midges, notwithstanding their mosquito-like appearance, being unable as well as indisposed to bite. They become troublesome only to those who do not understand their nature when they appear in our water supply, as they sometimes do, whether this comes from springs or other superficial sources, or is exposed to the air for a time in an open reservoir. They are occasionally seen in the Urbana tap-water, although so rarely that I have never seen them there myself, and I am writing this note merely to assure the people of the town that they are not in the least injurious or dangerous and that their occasional appearance here means nothing at all except that the female harlequin fly has deposited some eggs in the water works reservoir. Mr. Malloch of my staff has reared and identified our water works larvae and finds it identical with a widespread species occurring abundantly in waters of various description in nearly all parts of the state.

(Signed) STEPHEN A. FORBES,
State Entomologist.

Now we found in order to clean our filtered water basin it would be necessary to pump unfiltered water into town for a couple of days, so we built another filtered water basin and connected the two together with an 18-in. pipe and so arranging the pipe connections that we are able to deliver filtered water into either one or both. Also, we laid a new 18-in. suction line by passing either basin so that with the present arrangement, we can clean either basin without interfering with the service.

This new basin was completed in July and we have cleaned the basins a number of times, each time finding fewer of the larvae present in the basins. We feel that we have broken up the larvae nest.

---

*From paper before annual convention of Illinois Section, American Water Works Association.

THE BUBBLY CREEK WATER SOFTENING PLANT.*

By C. A. Jennings, Superintendent of Filtration, Union Stock Yards, Chicago.

The Bubbly Creek filtration plant at the Chicago Union Stock Yards requires no introduction. It has stood in a class by itself purifying probably the most polluted supply of any water purification system in the country. It was at this plant that hypochlorite of lime was first used on a practical scale for water disinfection—in the summer of 1908. Numerous articles have appeared about this plant, its operation and the wonderful results obtained. The results have been uniformly good. To many people the results have been almost unbelievable.

The Bubbly Creek water-softening plant is in its infancy and needs an introduction. At the present time the record of the filtration plant is much better than is that of the softening plant, as will be explained later. The plants are one and the same.

An agreement was entered into with the city of Chicago several years ago about the use of the filtered water from the Bubbly Creek plant. Since that time, the filtered water has not been used for watering live stock, but its use has been confined to mechanical purposes. At no time, however, has the purification been discontinued—as much care is being used now to obtain a satisfactory degree of purity at all times as was used formerly.

The conditions and problem to be met with in order to soften the water with this plant, were somewhat novel and peculiar to local conditions. The power house of the Union Stock Yard & Transit Co. (the same company that owns the filtration plant) is nearby. The boilers there require about 125,000 gal. of water per day. Previously they have been supplied with the returns from the heating system (some 50,000 or 60,000 gal. per day) and the balance of the water was taken from the Permutit system softening city water. The Chicago Junction Railway has some 50 or 55 locomotives operating in the Stock Yards. They have been supplied with filtered water that was not softened. The amount used averages about 600,000 gal. per day. Considerable filtered water has been used for flushing, for a high pressure fire system, and for condensing purposes.

It was decided to soften the water from Bubbly Creek and use it for the same purposes as heretofore, and, in addition, in the boilers in the power house, replacing city water softened by the Permutit system.

The filtration plant was designed for 5,000,000 gal. per day, with a period of coagulation and sedimentation of three hours. For several years, only one chemical-alum had been used as a coagulant. Mixture with the raw water was secured by introducing the solution into the suction of the low service centrifugal pump because the over-and-under baffles originally in the mixing canal had to be taken out, as it was impossible to flush out the settled sludge from the bottom of this canal. End baffles on 18-in. centers were installed in the mixing canal in preparation for softening the water. These give a fair but not satisfactory agitation and mixing. Mechanical agitators, air agitation and a false floor in the mixing canal to reduce the depth from 20 to 6 or 8 ft. have been considered as possible solutions for this trouble.

From an analysis of an average sample of the raw water, it should require 6.5 grains per gallon lime, 2.1 g. p. g. of soda ash and from practical experience about 1.25 g. p. g. alum in the treatment of this water. Various quantities of chemicals have been tried, starting with lime, 7 g. p. g.; soda ash, 2.1 g. p. g., and alum, 1.25 g. p. g., and now with lime 9.0 g. p. g., soda ash 3.1 g. p. g., and iron sulphate 1.5 g. p. g. The substitution of sulphate of iron for alum was made because the former could be used equally as well and was much cheaper. Alum was being quoted at $20 per ton (and is even considerably higher than that now), while sulphate of iron was quoted at $11 per ton. At the figures given as the present quantities of chemicals being used, the chemical cost for softening is 2.38 ct. per 1,000 gal.

The water would have been uniformly softened (but not to the limit) except for several reasons. As mentioned above, the plant was designed for 5,000,000 gal. per day and at that rate the settling basins have a three-hour capacity. The consumption of the filtered and softened water, varied from a rate of 500,000 gal. to 2,500,000 gal. per day. The clear water storage well beneath the filters has a capacity of 250,000 gal. or about 2½ hours' supply at the maximum rate of pumpage. With this variable rate of consumption, the period of coagulation, and sedimentation varied from 15 hours to 6 hours. The hardness of the raw water, which receives all kinds of sewage and trade wastes, varies from 10 to 15 grains per gallon. The hardness of the softened water has varied from 5.5 to 7 grains per gallon as the conditions varied.

The softening process at the Bubbly Creek plant has been in operation less than two months. A number of changes have been made and the results have been bettered. It is hoped that even more can be accomplished by means of changes now being contemplated.

CONCRETE SEWER CONSTRUCTION IN SOUTH BEND, IND.*

By W. E. Graves, Assistant City Engineer, South Bend, Ind.

The history of concrete sewers in South Bend bears a close resemblance to a history of the concrete sewer industry, dating its first experiment back to a time when that form of sewer construction was in its infancy.

On June 15, 1874, the common council of South Bend passed an ordinance providing for the construction of a concrete pipe sewer on Michigan St., from Washington St. to Wayne St. The specifications called for hydraulic cement. The pipe, manufactured by Millen & Greenawalt, was of the elliptical pattern, 24x30 in. inside measurement, about 4 in. thick, and without reinforcement.

The work was begun early in September and was probably finished about the last of the same month. The cost of this sewer was $2.65 per foot, and the depth varied from 11.5 to 8.8 ft. This sewer was still rendering service until the construction of the new trunk sewer during the past year.

Our next venture in concrete sewer construction was in 1904, when what is known as the Fassnacht Ave. sewer was constructed, containing 1,670 ft. of sewer 72 in. in diameter, and 1,773 ft. of sewer 66 in. in diameter.

Bids were received on several kinds of construction, including brick, two bricks thick, and the lowest bid was received on monolithic concrete.

The concrete was constructed 8½ in. thick, mixed in the proportions of 1 part cement, 2 parts sand and 4 parts gravel, and deposited wet enough to run in place without tamping. The cost was $9.75 per foot for the entire contract. It was reinforced with steel bands. In 1906 this sewer was extended 2,444 ft., under the name of the Kenwood Ave. sewer. The specifications were the same as above. The size was 66 ins., inside diameter. The work was done by a local firm, Hoban & Roach, at a cost of $9.50 per lineal foot. The depth of the Fassnacht Ave. sewer averages about 18 ft. and that of the Kenwood Ave. sewer about 16 ft.

In 1909 a contract was let to O'Shea & Shea of Hammond, Ind., for the extension of the above named sewer, under the name of Meade and Olive St. Trunk Sewer, by the addition of 1,017 ft. of 66-in. sewer at a cost of $6.50 per foot, 3,188 ft. of 60-in. sewer at a cost of $6 per foot, 1,995 ft. of 54-in. sewer at a cost of $5.25 per foot, 1,253 ft. of 48-in. sewer at a cost of $5 per foot, and 1,521 ft. of 42-in. sewer at a cost of $4.50 per foot. This time the choice fell to "Jackson Reinforced Concrete Pipe." The pipe was manufactured on the line of the sewer by the Jackson Concrete Pipe Co., and all other work was done by the sewer contractor.

A dispute having arisen between the inspector and the pipe company as to the advisability of using certain pipes which showed slight checks inside, on the side resting on the ground while seasoning, it was decided, at the suggestion of the company, to make a comparative test of one of these pipes and one which contained no flaws.

---

*Paper before 1916 annual meeting Illinois Section, American Water Works Association.

*Paper before annual convention of Indiana Engineering Society.

Two pipes 66 in. inside diameter were selected, one having checks on two sides, and the other apparently flawless. The pipes were imbedded in the ground to a depth of one-third of their diameter, a saddle made of planks placed on top and the pipe loaded with pig iron.

Twelve tons of iron were placed on the checked pipe and allowed to stand a week. The checks opened somewhat and cracks appeared on the outside midway between the inside cracks, but did not open very much after the first day. The load was then increased to 24 tons and allowed to stand 24 hours, but the pipe still refused to collapse.

The flawless pipe was then loaded in the same manner and was allowed to stand for 24 hours. When the load reached nine tons the four cracks appeared in the same position as in the one previously tested, and when the 24-ton load was reached it was in fully as bad condition as the one previously tested.

Three other sewers constructed of Jackson Reinforced Concrete Pipe, one in 1908, one in 1914 and one in 1915, are here passed as containing no new features. The Michigan Street Trunk Sewer was constructed in 1915 by J. H. Cahill of Louisville, Ky. This sewer is of three sizes, 60 in. in diameter at $12.73 per foot, 54 in. at $11.17, and 48 in. at $9.73 per foot. The average depth was over 20 ft. Bids were received on various materials, as usual, and the Merriweather Lock Joint Reinforced Concrete Pipe was adopted. The heavy traffic on this street made it desirable to use pipe, as it was not necessary to obstruct as much of the street as if a monolithic sewer had been constructed.

All these sewers are in good shape at present, which leads me to conclude that concrete is a safe and economical material for sewer construction. For small-sized sewers it may be used either with or without reinforcement, and with proper reinforcement it is suitable for sewers of any size.

CONSTRUCTING A THOUSAND-TON CONCRETE BLOCK FOR A JETTY HEAD.

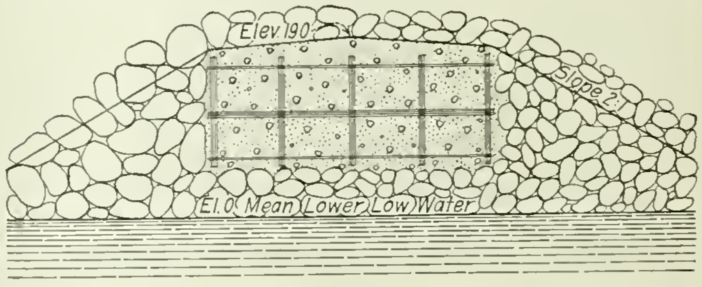
By Geo. F. Whittemore, Junior Engineer, U. S. Engineer Corps.

The concrete block was built at the end of the South Jetty at the entrance to Humboldt Bay, California. The location of the block is indicated by Fig. 1; it averages about 30 ft. wide and about 14 ft. deep; it contains 473 cu. yd. and weighs 950 tons. In construction, the concrete block is monolithic and is reinforced with 196 linear feet of old 60-lb. steel rails laid horizontally and transversely, 250 linear feet of old 50-lb. steel rails set vertically, and 350 ft. of old ⅝-in. plough-steel cables placed horizontally and binding the vertical members together near their ends. The vertical and horizontal members were bound together by clamps made of ⅝-in. round steel in the form of U-bolts (see Fig. 2, plan and cross section of block and Fig. 5). This arrangement of reinforcement was such as to afford the least interference with the pouring of concrete by bucket. The concrete was about a 1:2:4 mixture with crusher run stone. The total concreting time was 55 hours of which 11 hours were lost due to delays.

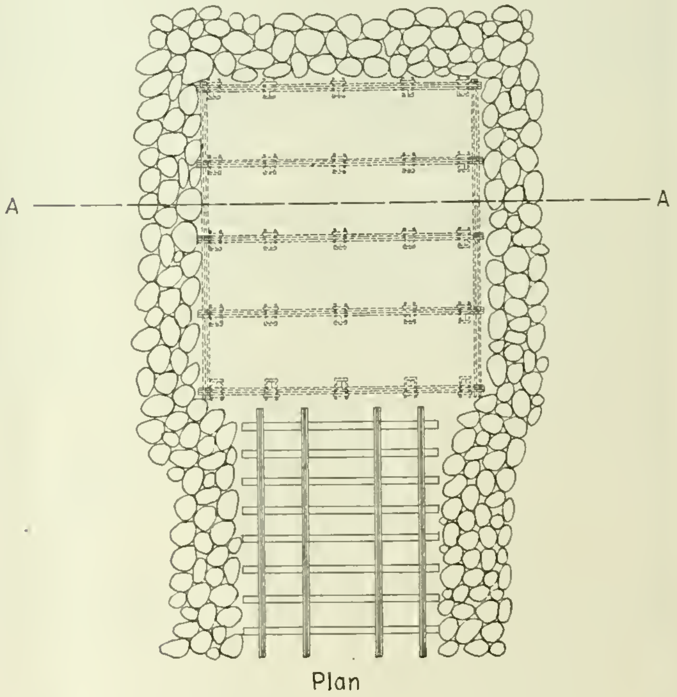
Plant.—The material was deposited by the crane (used for building enrockment) with a maximum radius of 50 ft., using a tripbucket of 1-yd. capacity, revolving through an arc of about 180 degrees from the mixer to the concrete block. The mixer is a "Foote Batch" of 1-yd. capacity, operated by steam and mounted on a standard gage car (extra reinforced) which carries 125 sacks of cement, 850 gal. of oil, 4,000 gal. of water, and 10 yd. of crushed stone. Alongside, on the other track (standard gage), is placed the sand car and behind it (shoreward) the cement car. These operations were 1⅝ miles from the yards, shops and bunk-house. Two 35-ton locomotives were used. The crushed stone was delivered on flat cars loose, and had to be shoveled into skips, each of 6½ tons capacity, with three to a car.

Crews.—Double crews were used; each crew was composed of: 1 foreman at block; 1 engine-man on mixer; 2 train crews; 1 mechanic in shops who tended engine for pump and dynamo, and made repairs; 1 foreman in yard; 1 store-keeper; 5 laborers to tamp and spread; 6 laborers on mixer car; 1 laborer to handle bucket; 7 laborers in yard to shovel crushed stone into skips; 1 timekeeper. The two locomotives and mixer were in constant use. One locomotive tended the crew and brought materials in and out from the yard, while the other kept water supplied to the mixer tank by means of her two injectors. The locomotive tank, holding 1,000 gal., had to be replenished every six hours.

Preparatory Work.—On the work preparatory to laying this block, the crane rails were extended to middle of block, 15 ft. out, on a temporary fill of larger stones. The encircling wall was then laid for the monolith. The inner walls were nearly vertical and were built with the largest selected stone to 22 ft. above M. L. L. W. and were laid on the horizontal-arch principle to resist the sea's thrust. The slopes were built about 1:1 only, on sides, in order to hasten the time of commencement of construction of block, to take advantage of suitable tides. The outer end of wall was less than 1:1, owing to lack of reach of crane. But to offset this, the wall was carefully laid outside with the largest stones. Great care, however, was taken to have a good true slope below low water, as scouring and under-mining were feared at the end of the jetty, where the currents are very strong.



Section A-A



Plan

Fig. 1—Concrete Block Jetty Head.

After the encircling wall was built around the site of future block, the work of excavating the inner half (which had been partially filled with stone to afford support for crane) was begun June 21. When the pit had been excavated to about +5 feet, attempts were made to make the bottom and sides (to 10 ft. above datum) watertight, by lining with concrete a foot or so thick.

As smooth weather obtained at this time, this succeeded remarkably well until the highest tide, when the seas broke through around some larger-sized stone in the northwest corner of the floor; but this did not interfere with the work. Later on, the southern inner face of concrete wall was washed in but, as the monolith was well up to 9 ft. above M. L. L. W., the damage was slight. At this time, the concrete walls were carried on up to 18 ft. above datum, and afforded perfect protection.

---

*Extract from an article in "Professional Memoirs" for Jan.-Feb., 1916.

Procedure.—The crushed rock was shoveled in yard from cars into skips and taken to mixer, where they were unloaded every hour by crane into mixer-hopper. The sand was supplied to mixer in sacks from a car spotted alongside. The cement was carried by hand (as needed by batch) from a car just behind the mixer car. The concrete, when mixed, was poured into a self-dumping bucket (1 yd.) and deposited in the block by crane. An average of 20 buckets was placed an hour. The batch was seldom more than 0.6 yd., on account of difficulty in mixing properly. The concrete was deposited very irregularly as to strata depths and lengths, on account of the sea water that slopped over the walls at high water. By keeping the drainage flat and employing one man to sweep off the sea water, very little damage was done, as the outer or wet end was worked at low water when dry, so that it was quite hard by the time of high water, when the dry or inner end of the block was worked.

COSTS.

Preparing pit-labor	$ 83.66
Laying block—Labor and superintendence	737.26
Materials (f. o. b. South jetty):	
Cable, no value.	
Rails, 4 tons at $0.15	60.00
Cement, 704 bbl. at $2.20	1,548.80
Rock, 464 yd. at $2.17	1,006.88
Sand, 74 yd. at $0.40	29.60
Extras:	
Oil, 900 gal. at $0.02½	22.50
Coal oil, 80 gal. at $0.09	7.20
Lumber, 1,000 ft. at $12	12.00
Extra lanterns, one-half value of 1 dozen at $9	4.50
Rent of carbide lamps at $5	5.00
Total	$3,517.40

SOME DATA ON HOLLOW BUILDING TILE.

The following data on hollow building tile were compiled by A. V. Bleininger, of the U. S. Bureau of Standards, and reported in the Brick and Clay Record:

Hollow Building Tile and Fireproofing.—The use, in the form of hollow tile, of larger units than brick is growing rapidly in the favor of the building public. Of these units a considerable number of sizes are made, without webs or with webs in one or both directions. Interlocking tiles have also come into use to a considerable extent. Two classes of tile may be distinguished, one in which the tiles are placed vertically and the other in which they are set in a horizontal position. These tiles are being used both for bearing and non-bearing walls. For the former only hard-burned tile can be considered, while soft material is well suited for partition walls. Hollow tiles are particularly useful for enclosure walls of steel or concrete skeleton structures and for stucco work.

The crushing strength of single tiles, hard burned, may vary from 4,000 to 10,000 lb. per square inch of effective area, and the modulus of elasticity from 3,000,000 to 5,000,000. Quoting from specifications proposed by the Hollow Building Tile Manufacturers' Association: "All tiles shall be true, straight and free from objectionable cracks, shall be well burned and of sufficient hardness not to absorb more than 10 per cent of their weight of water in a 48-hour absorption test, and shall have an ultimate crushing strength of not less than 3,000 lb. per square inch of net web area tested * * *." "No tile in any wall shall be loaded, including all live and dead load, so as to exceed 200 lb. per square inch of its bearing members. No hollow tile shall contain any void whose cross sectional dimension, measured at right angles to the web, is more than 4 in., and the vertical webs and shells of all tiles used for all bearing walls shall have a thickness of not less than 15 per cent of the measurements across the void enclosed by such shells or webs." * * * "For a one-story building the thickness of the wall shall not be less than 6 in.; for a two-story building, 8 and 6 in.; for a three-story structure, 8, and beyond the second story, 6 in.; for a four-story building, 12 in. for the first and second story, 8 in. for the third and 6 in. for the fourth story.

Strength of Hollow Tile Wall Sections.—It is evident that, in construction of this kind, the most important information is obtained from the testing of built-up wall sections and piers. A considerable amount of this work has been done by the National Fireproofing Co. and other firms. Some results of such work are given in Table I, most of which were compiled by E. V. Johnson, formerly vice-president of the National Fireproofing Co.:

From these tests it appears that the quality of the mortar, as is the case with brick, is a most important function. In the examples where lime-cement mortars were used the addition of cement was quite small. The laying of tiles in the vertical position is greatly facilitated by the use of strips of wire screens, which also impart to the wall a very high degree of rigidity.

The stability of tile walls is very marked indeed, and may exceed that of brick walls of equivalent dimensions. In regard to the fire-resisting quality of tiles the same conditions prevail which have been mentioned under the head of brick. Where this quality is to be emphasized a certain degree of porosity is essential. This applies especially to fireproofing used for the protection of steel columns and girders.

For this purpose products made from No. 2 fire clays are especially suitable, as they are of a porous nature and are able to withstand any high temperatures. Very low-fusing clays which vitrify easily should not be used for fireproofing purposes.

The subject of tile floors and arches and of combined tile and concrete construction is a large one, and the testing data available are not extensive. The large and successful use of tiles for this purpose seems to prove the worth of this material.

The excellent thermal non-conducting quality of hollow tiles makes them particularly desirable for residence construction. This statement applies, of course, only to atmospheric temperatures. A hollow tile wall would not be desirable for furnace walls, owing to the rapid increase of heat loss by radiation through the air spaces with increase of temperature.

Architectural Terra Cotta.—What has been said of the strength of burnt clay in the form of tiles applies also to terra cotta. The data available on this subject are very

TABLE I.—RESULTS OF TESTS OF HOLLOW TILE WALL SECTIONS.

Construction of section.	Outside dimensions. Height.	Width.	Thickness.	Net area, sq. in.	Mortar.	Total maximum load.	Maximum load per sq. in. of net area.
Two 4-in. tile	7 ft 7¾ in.	8⅜ in.	8⅜ in.	56.0	Cement 1:3	98.81 tons	6,873
Two 4-in. tile	8 ft. 4 in.	8⅜ in.	8⅜ in.	56.0	Cement 1:3	141.30 tons	5,065
8x12x8-in. tile	11 ft. 9¾ in.	36½ in.	8¼ in.	144.0	Cement 1:3	506,000 lb.	3,514
8x12x8-in. tile	12 ft. 1 in.	37 in.	8¼ in.	144.0	Cement 1:3	346,000 lb.	2,403
11¾x11¾x4-in. tile	12 ft. ⅝ in.	25⅝ in.	8¾ in.	120.6	Lime-cement	136.0 tons	2,255
8¼x16x8⅛-in. tile, cross webs	11 ft. 11¼ in.	32⅞ in.	8¼ in.	78.8	Lime-cement	43.5 tons	1,114
12x8x12-in. tile, webs vertical	12 ft. 2½ in.	36⅝ in.	8 in.	140.0	Cement 1:3	436,000 lb.	3,110
12x8x12-in. tile, webs vertical	12 ft. 4 in.	35 in.	7¾ in.	80.0	Cement 1:3	154,000 lb.	1,925
12x8x12-in. tile, 2 transverse, webs horizontal	12 ft. 4¼ in.	36¾ in.	7¾ in.	60.0	Cement 1:3	80,000 lb.	1,333
8x8x12-in. tile, side construction	11 ft. 11¾ in.	32⅞ in.	8¼ in.	76.0	Lime-cement	43.5 tons	1,144
Four-inch porous tile	12 ft. 6⅝ in.	34⅞ in.	3 5/16 in.	56.0	Lime-cement	27.0 tons	964
8x8x16-in. glazed tile, 3 transverse, webs vertical	12 ft. ¼ in.	32½ in.	8 in.	80.0	Lime-cement	84.0 tons	2,100
Double 4-in. partition, hard-burned tile	12 ft. ⅝ in.	35⅝ in.	8¾ in.	120.6	Lime-cement	136.0 tons	2,255
Four-inch partition, hard tile	12 ft. ⅝ in.	35⅝ in.	4 in.	60.3	Lime-cement	60.0 tons	1,990
Three-inch partition, hard tile	11 ft. 9¾ in.	34½ in.	3 in.	46.0	Lime-cement	54.0 tons	2,347
Partition of 4x8½x8-in. tile, plastered	12 ft. 3⅝ in.	34½ in.	5 3/16 in.	112.0	Cement 1:3	185.0 tons	3,303
Denison interlocking tile, tile wall, faced with brick	11 ft	5 ft. 1 in.	12½ in.	gross 762	Cement 1:3	686,000 lb.	.....

meager. The strength of terra cotta is not very important, inasmuch as this material is used principally for facing purposes, although it is usually well burned and of excellent strength. It is generally made from No. 2 fire clays, and, with an absorption of 10 per cent, shows an average crushing strength of not less than 4,000 lb. per square inch. The resistance to weathering of the glazes and enamels is to be considered, and it is essential that the covering slips and glazes be firmly united to the body of the ware and that the enamels be sufficiently resistant to make them waterproof. Freezing tests of terra cotta would be very desirable, and an acid test would gage the resistance of the enamels to atmospheric influences.

EXPERIENCE IN FURNISHING SAND AND GRAVEL FOR CONCRETE TO CONTRACTORS OF THE GREATER WINNIPEG WATER DISTRICT.*

By James H. Fuertes, Consulting Engineer.

Under the contracts awarded for the construction of the works, the District supplies its contractors with the cement, sand and gravel necessary for the construction of the works. The sand and gravel is delivered to the contractor on his platforms for 75 ct. per cubic yard, and the cement is delivered to the contractor at the cost to the District, which cost includes the cost of the cement, cost of inspection, handling, hauling and delivering of the cement to the contractor with a rebate for the sacks returned. The contractor's prices for concrete include the cost of the gravel and sand, but do not include the cost of the cement, the cement being charged to the contractor as it is delivered to him and credited as it is used in the work.

Under the adopted policy of supplying the contractors with sand and gravel the District has been obliged to open a large gravel pit and install excavating machinery, tracks, dinkey locomotives, dump cars and a plant for grading the materials. The materials excavated from the pit are brought to this plant on an elevated track in 6-yd. dump cars and dumped through a grizzly which leads to the foot of an elevator. The materials passing through the grizzly are carried by a belt and bucket elevator to a rotary screen in the top of the screen house which separates the material into three sizes. The screen is in three sections, one having ½-in. holes, the next having 1-in. holes and the last 2½-in. holes. Since the material, as excavated from the gravel pit, contains a small percentage of moisture, it was found impracticable to screen it through fine screens owing to the clogging of the meshes. After screening, the materials pass from the storage bins under the screen through chutes leading to a belt conveyor, upon which the different sizes of material are spouted from the bins in the correct proportions to form a concrete aggregate. From the belt the material discharges into the boot of a second elevator which raises it to the top of the screen house and dumps it upon other belt conveyors which drop it into storage bins from which the 20-yd. air dump cars are loaded. An inspector stands at the end of the lower belt conveyor and samples the materials carried by the belt, from time to time, and changes the proportions of fine, intermediate and coarse materials as required. The oversize which passes through the rotary screen, goes back to a jaw crusher, which breaks up the stones, and they in turn are thrown back through the boot under the grizzly and carried up again to the rotary screen. A gyratory crusher has also been installed at the foot of the grizzly for breaking up large stones which will not pass through the 3-in. spaces between bars of the grizzly. The storage bins have not as yet been a success, the difficulty being that as the material drops from the belt into the bins the sand falls straight down and the stones, jumping further, run down the outside; this produces a very extensive segregation of the materials. Devices are now being installed, however, to prevent this so that the storage capacity of these bins may be utilized. Up to the present time the only extra storage that has been available at the plant has been in the 20-yd. air dump cars. The material is spouted directly to these cars from the belt without appreciable segregation. The plan proposed for preventing the segregation of the materials in the storage bins is to have a vertical telescopic chute in sections, hung at the end of each belt so that the materials will fall down through this chute; and as the chute fills up the lower sections will be raised progressively to allow the materials to spread as the bin fills up. It is a device used extensively in collieries to prevent the breaking up of the coal when loading into storage bins, and it is believed it will work successfully to prevent the segregation of the materials as loaded into the storage bins. No difficulty will be experienced in loading materials from the storage bins to the cars.

Characteristics of Concrete Aggregate.—Owing to the percentage of sand in the gravel pit it is necessary to dig considerably more material than can be made into concrete aggregate. Thus during August there was excavated at the pit approximately 24,000 cu. yd. of material, of which 6,000 cu. yd. was stripping and 18,000 cu. yd. of sand and gravel; of the 18,000 cu. yd., 13,000 cu. yd. were concrete aggregate, a large proportion of which contained 50 per cent of sand, and 5,000 cu. yd. was ballast and foundation fill material. It is desirable that the percentage of sand in the concrete aggregate should not exceed 35 per cent of the whole in order to have an economical concrete. With a larger percentage of sand the amount of cement required to make a water-tight concrete has to be increased. Studies are being made of means of operating the pit in such a way as to reduce the amount of extra excavation considerably. The screening plant can turn out 100 cu. yd. per hour of sized and mixed material without difficulty, but when the material comes to the plant from the pit with 60 per cent to 75 per cent sand it chokes the hoppers and reduces the output aggregate. In order to avoid delaying the contractor by shortage of gravel during the coming year it has been decided to open another gravel pit near the eastern end of the work, at about mile 80, of as great a capacity as the existing plant, which is near the western end of the work between miles 30 and 31.

Under the terms of the contract the District agrees to deliver the sand and gravel to the contractor at a stated price per cubic yard. Actually the District is shipping these mixed, but billed as sand and gravel in accordance with the ratios of the volumes that the sand and gravel would make separately, these having been determined from an extended laboratory study of the materials. It would be impossible, within the limits of the present paper, to do justice to this phase of the subject, but it may be noted that with a proper proportioning of the materials, particularly of the sand, by using certain percentages of sand passing the 100-mesh screen, it was possible to make concrete that was water-tight under 80 lb. pressure per square inch, with about one Canadian barrel of cement per cubic yard of concrete. The Canadian barrel contains 350 lb. of cement, instead of about 384 lb., the customary net weight of the U. S. barrel.

From a long series of samples of the materials from test pits in the gravel deposits at the pit it was found that the average run of the better samples contained about 3.3 per cent of fine sand passing the 100-mesh sieve, the percentage of sand to total aggregate varying between quite wide limits. It was also recognized that it would be desirable from the point of view of economical development to use as large a proportion of sand in the final aggregate as safety would permit, bearing in mind that the amount of cement required to make tight concrete should be kept to a minimum. The allowable percentage of sand was finally fixed at 35 per cent of the total aggregate, by weight, and the series of tests for permeability, above recorded, are based largely on this percentage, although a few tests were made with larger and smaller percentages.

Figure 1 shows the percentages of fine sand (passing the 100-mesh sieve) required to make water-tight concrete with 10 per cent of cement (370 lb. of cement per cubic yard of set concrete) when the sand is 35 per cent by weight of the total aggregate, with varying percentages of intermediate and coarse materials.

---

*Extracts from a paper read before the Western Society of Engineers, Oct. 18, 1915.

Using 12 per cent cement, with sand having 3.3 per cent passing the 100-mesh sieve, water-tight concrete could be made with sand varying from 23 per cent to 43 per cent of total aggregate and with intermediate and coarse, in equal proportions varying from 77 per cent to 57 per cent, respectively, or, if coarse were absent, with sand at 35 per cent and intermediate at 65 per cent. Fairly good results were obtained with 12 per cent cement even with 49 per cent sand and 51 per cent intermediate, but this concrete slowly absorbed considerable water, showing a fairly large percentage of very small voids.

In order to be on the side of safety, in starting a new plant, the minimum quantity of cement that has been used when aggregate containing 35 per cent sand has been shipped out has been 12 per cent, corresponding to about 1.27 bbl. (Canadian) to the cubic yard. The first cut in the gravel pit, arranged for a convenient layout for operating conditions has taken the excavating machines into a part of the deposits running high in sand, and, in order to keep the total sand in the finished aggregate down to 35 per cent required a considerable wastage of sand after screening, which cuts down the net output and increases the amount of material to be handled. As the demands of the contractors have taxed the plant heavily, due to a number of causes, among which were delays due to breaks in machinery, lack of storage for the mixed aggregate, shortage of cars at times when the haul was long, or when large amounts of foundation fill materials were being shipped, it was found necessary, at times, to ship out material containing 50 per cent sand, and in some cases pit-run material. In such cases the cement has been increased to about 15 per cent or 1.7 bbl. (Canadian) per cubic yard. This policy is very expensive, however, as it increases the cost of concrete to the District by about $1 per cubic yard, net, over the cost of concrete made with an aggregate containing 35 per cent of sand. As the estimated volume of concrete in the whole aqueduct is about 330,000 cu. yd., the District is, this winter, planning to open another pit, equipped somewhat differently, near the eastern end of the line, to relieve the pressure on the existing plant both by furnishing more aggregate and by shortening the haul, thus getting better efficiency out of the transportation equipment.

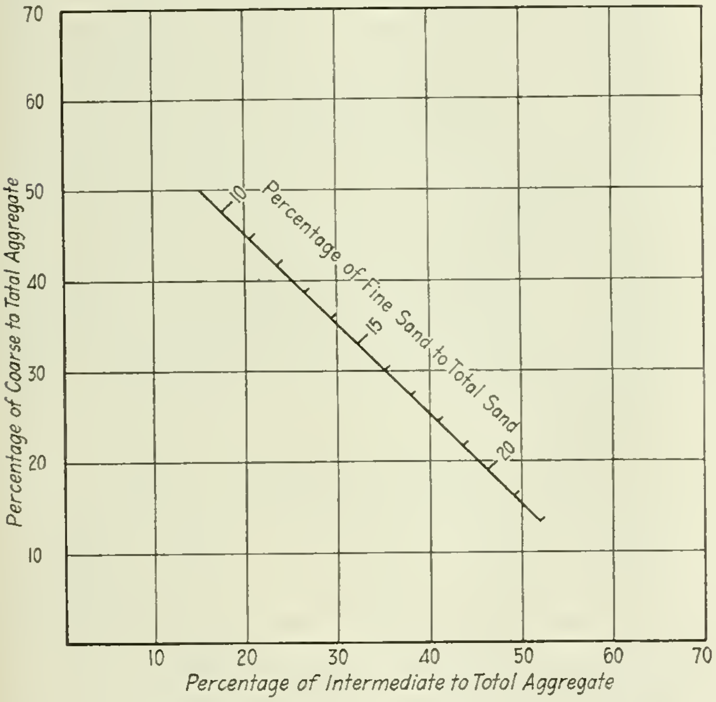


Fig. 1—Sand Percentage for Water Tight Concrete.

The mixed sand and gravel is loaded into 20-yd. air-dump cars at the screening plant, hauled to the contractor's platforms and dumped. The cars are loaded, as nearly as possible to a loose measurement of 23 cu. yd., then scaled, and billed out to the nearest even yard below the scaling. Of 110 cars loaded and billed out in one test, 15 contained by scaling 22 cu. yd., 75 contained 23 cu. yd., 19 contained 24 cu. yd. and one contained 25 cu. yd. The total measured yardage in the cars was 2583.1 cu. yd. and the total billing was 2536 cu. yd., a difference of 47.1 cu. yd. or 1.85 per cent more material shipped than billed for, due to taking the nearest even yard below the scaling; or, roughly, the deliveries averaged nearly half a yard per car in excess of the billing. A further excess of deliveries over billing in cars leveled off for measurement also arises from the mechanical effect of the consolidation of the material in the cars of measured aggregate by the men when leveling off the cars. For example 17 cars were measured at the plant, then leveled off and trimmed. Before leveling, the measured content was 392 cu. yd. and after leveling off 380.6 cu. yd., a difference of 11.4 cu. yd., or 3 per cent shrinkage due to consolidation by the men's feet.

The relative weights of the aggregate per cubic foot under different conditions as to moisture and compacting is shown in the following table, the sand in the moist aggregate being about 37 per cent by weight.

Weight per cu. ft. loose and moist	114 lb.
Weight per cu. ft. shaken and moist	122 lb.
Weight per cu. ft. tamped and moist	132.5 lb.
Weight per cu. ft. loose and dry	125.0 lb.

from which it will be seen that the percentage shrinkage from the loose and moist condition to loose and dry was 9.65 per cent and to shaken and moist 7 per cent and to tamped and moist 15.8 per cent.

The shrinkage in volume during transportation from the pit at mile 30.8 to different points along the line is shown in Table I.

TABLE I.—SHRINKAGE IN YARDAGE OF AGGREGATE DURING SHIPMENT FROM MILE 30.8 TO DIFFERENT POINTS ALONG THE AQUEDUCT LINE.

(Aggregate 50 per cent sand; 4 cu. ft. cement to 16 cu. ft. aggregate = about 1.7 bbl. cement per cubic yard of concrete.)

Date.	Mile at which sand was delivered.	Cu. yd. billed.	Cu. yd. measured at pit.	Cu. yd. at plant after leveling and trimming.	Cu. yd. as measured at point of delivery.	Ratio of cu. yd. billed to cu. yd. measured at delivery.	Ratio of cu. yd. measured to cu. yd. delivered and measured there.
Aug. 26	40	23	23.6	22.2	21.8	1.055	1.08
Aug. 26	43	46	46.6	44.2	43.3	1.060	1.08
Aug. 27	51	46	46.2	46.2	42.2	1.090	1.09
Aug. 27	57	69	69.6	67.8	66.6	1.045	1.055
Aug. 27	65	69	*68.1	68.1	64.1	1.075	1.06
Aug. 27	71	45	45.4	44.3	41.5	1.085	1.095
Aug. 27	77	45	45.4	44.8	40.8	1.100	1.110
Aug. 27	85	46	45.8	45.0	42.4	†1.085	1.08

*Car leveled up for measurement at plant and settled in process of leveling.

†Side doors of car raised in transit about 2 ins. and some material leaked out.

In order to determine the ratio of aggregate billed out from the plant to the yardage of concrete put in place, measurements of both aggregate yardage and yardage of concrete laid were kept by all the division engineers for a week. Owing to inaccuracies in trimming the bottoms of trenches and to the small excess quantities of concrete in the arch sections, due to hand finishing the tops a little higher than the theoretical lines, the payment concrete averages less than the actual quantities placed. These ratios are shown to be about as follows:

Total cubic yards of aggregate billed	= 3,633.2	
Total cubic yards of concrete laid	= 3,422.7	
Excess of aggregate over total concrete	210.5	= 6%
Total cubic yards of aggregate billed	= 3,633.2	
Total cubic yards of payment concrete	= 3,310.7	
Excess of aggregate over payment concrete	322.5	= 10%
Yardage of total concrete	= 3,422.7	
Yardage of payment concrete	= 3,310.7	
Yardage of excess concrete	= 112.0	= 3.4%

Costs of Preparing Aggregate.—The average cost per cubic yard of the aggregate, for preparation exclusive of overhead charges, and transportation to the contractor's platforms, has been as follows:

Excavation	$0.118
Hauling to plant	.031
Screening and crushing	.139
Loading	.061
Repairs to plant	.019
Repairs to cars, crane and dinkey	.011
Office	.005
Fuel	.123
Total	$0.507

It is expected that this cost will be materially reduced during the coming season.

A LABOR COST-KEEPING SYSTEM FOR CONCRETE BRIDGE WORK.

Contributed by R. A. Small, Constructing Engineer, Lansing, Mich.

On small jobs where one man constitutes both office and executive force, elaborate cost-keeping systems are cumbersome, uncertain, and impracticable; yet cost data are as important to the small contractor as to the large one. The following is a description of the labor cost-keeping system used with satisfactory results on bridge work by the writer's firm. Materials are not entered because the cost of materials is practically known before the job is started, and labor is the chief variable.

The "Daily Time Book" used is a small loose-leaf notebook, quad-ruled and alphabetically indexed (see Form 1). This type of book is used because of its elasticity of record and also because it is convenient to have extra detachable note paper combined in a form to fit the trouser's pocket. On the fly-leaf pages there is written a consecutive list showing the number, name and class of each employe, reserving four columns at the right of each page, lettered A, B, C and D, on which each man's proven degree of efficiency is indicated. No number is subsequently given to another man on the same gang.

Under index "C" there is written the code adopted for the job in hand, so arranged that the subdivisions open on opposite pages; the main divisions are more easily remembered. Last season's code is shown herewith, the code being self-explanatory:

Main Divisions—Initial Letter.

B	Brickwork.
C	Concrete.
D	Dams, cofferdams, sheet piling.
E	Excavation; EW, wet.
F	Forms; FW, wood; FS, steel.
H	Housing, weather protection.
K	Concrete surface finish.
L	Lumber.
N	Piles, bearing, round.
O	Old structures.
P	Plant.
R	Reinforcement.
S	Stonework.
T	Traffic structures, temporary.
W	Woodwork, not forms.
X	Extras.
Z	Miscellaneous.

Subdivisions—Kind of Work—Second Letter.

a	making, preparing, mixing.
e	erecting, placing, building.
i	removing, stripping, cutting away.
o	repairing.
u	receiving, storing, reloading.
E	Excavating Only.
a	excavating.
e	backfilling.
i	pumping.
o	grading.
u	drilling.

Concrete Surface Finish.

a	picking.
e	plastering.
i	rubbing.
o	repairing.
u	grano finish, integral.
ua	grano finish, not integral.

Subdivisions—Location of Work—Third Letter.

a	arch.
b	abutments.
bf	abutment footings.
d	drains.
f	floor.
fs	floor slab.
fb	floor beam.
ft	floor, tar treatment.
p	piers, pedestals.
pf	pier footings.
r	railing.
t	truss.
c	cement.
g	gravel.
tr	trestle.
s	steel reinforcement.

Under index "T" there is kept the daily time, an individual leaf being assigned to each man. Under a caption indicating the week there appears, at the left, the alphabetical code symbols indicating the work which the man performs, as shown in Form I, which is the page for workman No. 12 during the weeks 6/19-6/25, 7/10-7/16 and 7/17-7/23. Opposite the respective symbols, written as they occur, and under the figures showing the respective days of the month, there are written the actual numbers of hours devoted to the several portions of the work. Further check is afforded by small marks in the upper left-hand or right-hand corner of the entry square for A. M. and P. M. service, which, while not carried out very thoroughly has proven a valuable bit of evidence in case of dispute. It is worthy of note that no man has yet twice disputed this daily record. Total hours and wages are extended under proper headings opposite each symbol. These totals, when added, become a check on the extensions and help to exclude mathematical errors. The week closes Thursday night, so that there need be no hurry nor delay in delivering the pay-checks on Saturday night.

FORM. I.—SAMPLE LEAF OF DAILY TIME BOOK.

	No.	12			6/	19	—	6/	25						
			19	20	21	22	23	24	25		Hrs.		$		
E	Wa	b		8½		5½	1				15		3.	75	
					4	meal	s							80	
			Chk		M	46	bal						2.	95	
				7/	10	—	7/	16							
			10	11	12	13	14	15	16		Hrs.		$		
O	i b			7			2				9		2.	25	
F	W e	b	5	3		9½	7		1		25½		6.	38	
F	W o	b							2		2			50	
C	e b								7		7		1.	75	
			Chk	M	107						43½		10	88	
				7/	17	—	7/	23							
			17	18	19	20	21	22	23		Hrs.		$		
F	Wi	b	2	5							7		1.	75	
K	e b		2								2			50	
D	i b		6								6		1.	50	
E	W a	b		5		5					10		2.	50	
F	W a	b						4	6		10		2.	50	
R	e b	f				3	2				5		1.	25	
O	i b					2	2	6	3		13		3.	25	
C	a b	f					3				3			75	
C	u	c							1		1			25	
L	u						3				3			74	
			Chk	M	114	$5	M	112	$5		60		15	00	

The "Summary Book" is a quad-ruled, bound, end-opening notebook containing each man's weekly record entered up in the same manner as the daily record, so that the complete record for the week appears on opposite pages in case of a large number of entries (see Form II).

"Week" and "Job" totals are extended at the right, together with the respective units completed and their unit prices, so that one not only can ascertain his gross costs but also has available a valuable current weekly comparison and check on his work. Clerical and mathematical errors are detected by adding the columns both ways. Work completed previous to or discontinued during the current week is not written forward until the week during which further labor is specifically applied on it. This requires the copying of figures carried forward, but it permits the use of a pocket-size book.

FORM II.—WEEKLY SUMMARY AND JOB TO DATE.

														7/	10	—	7/	16											We	ek				J	ob to	Da	te	
		R	T	i	4		7		1	2	1	3	3	0	3	6	3	7	3	8	3	9	4	0		$		Un	its	U.	P.		$		Un	its	U.	P.
C_e^a bf	5	2.00					5	1.50			5	1.25	5	1.12	7	1.58										7	45	7½	cu.yd.	1.	00		27	35	27½	cu.yd.	1.	00
C_a^e b	6	2.40			7	1.75	1	.30	7	1.75			7	1.57			7	1.75	10	2.25	18	4.05	3	.75		16	57	31½	cu.yd.	.	53		16	57	31½	cu.yd.	.	53
FWeb	15½	6.20			22½	5.62	3	.90	25½	6.38	20½	5.12	19½	4.38	18½	4.16	9	2.25								35	01	1140	sq. ft.	.	0307		35	01	1140	sq. ft.	.	0307
FWab																			3	.67			3	.75		1	42	1140	sq. ft.	.	0013		1	42	1140	sq. ft.	.	0013
FWutr	8	3.20	5	2.50							8	2.00											4	1.00		8	70	41	poles	.	21		8	70	41	poles	.	21
Tofb	1	.40																									40							40				
Dop	2	.80									2	.50	2	.45					2	.45	2	.45				2	65						2	65				
FWob	4	1.60			8	2.00	4	1.20	2	.50					3	.67	3	.75								6	32	1140	sq. ft.	.	0059		6	72	1140	sq. ft.	.	0059
Oib	11	4.40					12	3.60	9	2.25	6	1.50	5	1.13												12	88	50	cu. ft.				12	88	500	cu. ft.		
Z	1	.40									2½	.63														1	03						21	91				
Cug			2	1.00																						1	00	1½	cu.yd.	.	66		87	39				
Reb					2	.50																					50	112	lbs.	.	005			50	112	lbi.	.	005
Eib											8	2.00														2	00						2	00				
Poi											2	.50															50						1	40				
Cuc																					5	1.12				1	12						16	48				
Totals	53½	21.40	7	3.50	39½	9.87	25	7.50	43½	10.88	54	13.50	38½	8.65	28½	6.41	19	4.75	15	3.37	25	5.62	10	2.50		97	95						667	24				

When a man's daily record is entered in the "Summary," the week is checked off to avoid delinquency in the records, and when his daily leaf is full a new leaf is placed under daily "T" for him and the old leaf is removed from "T" to the index letter of his last name after being fully entered up in the "Summary." Teams are designated T1, T2, T3, etc.

After each day's work the salient points are written up in a diary, as an aid to the memory, particularly on points having significance later. The diary is also used to trace the progress, as well as the particular conditions influencing the work, so that the summary costs can be properly interpreted. Weather conditions and water levels are always recorded. The job diary is a bound notebook, this form being used so that no entry can be written up later and inserted to suit events.

The foregoing cost-keeping system was adapted from systems described in Engineering and Contracting from time to time; it is easily maintained, and the data are kept in pocket-size books. Other systems of recording labor have been tried, but none have been found as satisfactory as the one described.

MAKING TIGHT JOINTS IN SUBMERGED SANITARY SEWERS ON CONEY ISLAND.

Extensive storm water and sanitary sewerage systems have been installed on Coney Island during recent years. The Island is a low-lying sand bar in which practically every sewer improvement is a pumping proposition of more or less magnitude. The 8 and 10 in. sanitary sewer pipe lines are laid on single 8-in. piles spaced 6 ft. on centers. On top of the pile is a 6x8-in. cap, and on the cap one thickness of 2-in. planking. The pipe is laid to its horizontal diameter in a concrete cradle which, for 8-in. pipe, is 17¼ in. wide by 8¾ in. high, and for 10-in. pipe is 19¾ in. by 9⅞ in. Great care was taken in the construction work, as pointed out by Frank J. Conlon in a paper before the Brooklyn Engineers' Club, which resulted in remarkably tight joints between the sewer pipes, which, as all of the sewage flow is pumped from the collecting well at the station, and treated, is of great consequence to the city in keeping down the cost of pumping. This entire system of sewers is laid under ground water, and at places under a constant head of from 6 to 10 ft., or even more, of water. Obtaining watertight joints under such conditions is very difficult, and has seldom been accomplished. The procedure in making tight joints was as follows:

The joints were made with rope yarn, soaked with cement grout, and well rammed into the annular space between the spigot and the bell for a depth of ¾ in., the remainder of the space being filled with cement mortar made of 1 part cement to 1 part sand.

In addition to this, the upper part of the joint, not embedded in the concrete cradle, is covered with a cement collar 3 in. thick. These joints have resisted the entrance of the water remarkably well and very little evidence of leakage has been found, but in later contracts provisions were made to introduce a waterproof compound in the joints in place of the cement-mortar filling; the specifications providing as follows:

> All pipe used in the sewer shall be vitrified stoneware pipe, laid in concrete cradle. All joints of the pipe sewer shall be made with a compound approved by the chief engineer. The compound shall preferably have a bituminous base, shall adhere firmly to the glazed surface of the pipe, shall melt and run freely at a temperature as low as 250° F., and when set shall be sufficiently elastic to permit of a slight movement of the pipes without injury to the joint or breaking the adhesion of the compound to the pipe. The compound shall not deteriorate when submerged in fresh or salt water or normal domestic sewage. It shall also show no deterioration of any kind when immersed for a period of five days in a 1 per cent hydrochloric acid solution, nor when immersed for five days in 5 per cent solution of caustic potash.
>
> The joints shall be carefully centered and calked in the usual manner. After the joint is properly calked, a suitable runner shall be placed, and the compound, heated to a temperature of approximately 400° F., shall be poured from one side so that it shall run around the pipe and fill the annular space to a point ½ in. inside the outer rim of the bell of the pipe. After the joints are run and concrete cradle placed, that part of the joint not embedded in the cradle shall be further protected with a cement-mortar casing extending to at least 3 in. from the face and outside of the bell. The cement-mortar shall be made of 1 part cement to 1 part of sand.

The joints on the sanitary house connections and standpipes are specified to be made in the same manner as the sewer joints.

CONCRETE SHAFT LINING; DEVELOPMENT OF FORM HANDLING AND CONCRETE PLACING METHODS.

II.

Introductory Discussion.

The permanent lining of shafts in American mining and tunneling is with concrete. In Europe linings of brick and cast iron are still common, but in America concrete lining is practically universal, except where timber is used in first construction to be replaced with concrete in final construction, or when steel is used encased in or in combination with concrete. The development of methods of concreting in shaft lining has been interesting in many particulars, and it has been within a period so recent that its essential features have been set down in the records of engineering construction. A review of these features based on cited examples is the object of this article.

Preceding the set task, it is important to note the influence that concrete lining has exerted on lined shaft design. Briefly summarized, in the problem of choosing shaft shapes concrete for lining has released the engineer from any necessity of adapting the cross-section to limitations imposed by rigidity of lining material; in varying thickness of lining and in reinforcing lining to meet localized or irregularly distributed pressures concrete has given the engineer an absolutely flexible material; in most shaft sinking concrete for lining, with its near relative, grouting, has given the engineer, it is not extravagant to assert, a method of construction without drains or pumps. These are all exceedingly valuable aids, and they are comparatively young in service.

Shaft-lining of concrete in the United States is only about twelve years old. Since in 1903 the first shaft was concrete lined at Tug River in West Virginia, there have been developed the following methods: (1) Monolithic lining laid against the walls and behind forms; (2) Drop shaft lining or lining by sinking and building up concrete caissons; (3) Lining of pre-cast concrete slabs, struts and beams; (4) Lining by shooting a concrete covering onto steel sets and lath. The method first named is the oldest and it is the normal method. Caisson sinking is practicable ordinarily only in earth. Drop shaft construction is in practice confined to sinking through earth overburden where this is rather thick and particularly when it carries water. It is a special process. Lining of pre-cast concrete slabs and framing is comparatively new; it is a method of replacing old lining units of timber or sometimes steel with similar units of cast concrete. Lining by plastering steel sets and lath is in the one example recorded rather a use of concrete as a protecting covering and seal than as a structural form. As a generality, then, concrete shaft lining is monolithic lining by depositing concrete against shaft walls and behind forms.

Monolithic lining was the method employed at the Tug River shaft and it is worthy of mention, perhaps, that in reviewing the account of this work in a succeeding paragraph the reader will note that the methods followed were in all details such as would be held good practice now after a dozen years' experience. Lining new shafts with concrete deposited in place behind forms follows one of two general methods of procedure. One is, with the shaft completely excavated, to begin lining at the bottom and proceed continuously to the top; the other is to build upward the lining in sections as the excavation progresses. The second procedure is the more common. It is more precisely as follows: After excavation has proceeded to a suitable depth lining is begun near the bottom of the excavation and is carried to the top; when another suitable depth below the first has been excavated, lining is again begun near the bottom and is carried up to a closure with the first section of lining; these processes are repeated until the full shaft depth is lined.

The reasons for the more common use of the sectional method seem to be mainly these: By simultaneous excavation and lining, the lined shaft is sooner finished; a less depth of shaft wall is at any time left unsupported and unprotected; seepage is confined and controlled as the work progresses. These advantages have opposed certain obvious disadvantages. The lining process is intermittent and in a measure hampered by the necessity of providing way for the excavating operations in progress lower down. Also the closure joints are tasks requiring some extra care and time.

In shaft lining by the method being considered, there is another set of modifications introduced when the task is to re-line an old timber-lined shaft. Here the lining work includes tearing out the old lining ahead of the new concrete lining and sometimes it includes trimming the rock walls. These tasks reduce the speed of lining by the time required to perform them, but in general the concreting processes are identical with those of lining a new shaft.

The items therefore to be regarded in concrete shaft lining are the same in all cases, and are: Materials and proportions for concrete; mixer plant location and arrangement; concrete conveying methods; forms and form handling; control of seepage, and closure joint construction. A citation of examples of practice is an essential preliminary to discussion of and conclusions regarding these items. Such examples follow, selected from many because of the precision with which the data have been recorded.

Illustrative Examples.

The examples selected are grouped to present first work of lining new shafts and second work of re-lining old shafts, but with no other attempt at systematic sequence.

Mine Shaft at Tug River, W. Va.—This shaft was the first shaft in the United States to be lined with concrete. The work was done in 1903. The shaft dimensions were 17⅓ ft. x 35 ft. inside, the section being elliptical, and the lining was 1 ft. thick at the sides and 1½ ft. thick at the ends. Figure 1 shows the mixing and concrete handling plants. Two buckets were employed, one always being in place to receive concrete from the mixer, and they were filled and lowered alternately. Figure 2 shows all essential details of a form ring; ten of these rings were constructed, being set one on top of another and connected by dowel pins as fast as the concrete filling required. When all 10 rings had been concreted further advance was made by removing the bottom ring and placing it on top as fast as filling required. Roofing paper strips were used to cover the expansion joints when filling. Two shifts were worked. One shift set a form ring, placing a platform on the top cross-ring bracing. The other shift concreted the ring; concrete was dumped on the platform and shoveled into place and settled by churning with a long, narrow spade, the mixture being wet. The form shift consisted of an engineer, headman, two carpenters and two helpers, and it set a ring of forms in 9 hours. There were 5.9 cu. yd. of concrete per foot depth of shift and it was placed at the following costs:

	Per foot.	Per cu. yd.
Materials:		
Stone	$ 5.90	$1.00
Sand	1.77	0.30
Cement	19.18	3.25
Total	$26.85	$4.55
Labor:		
Mixing	$ 3.83	$0.65
Placing	3.40	0.58
Fire and pumpmen	2.19	0.37
Total	$ 9.42	$1.60
Forms:		
Lumber at $13 per M	$ 1.83	$0.31
Making at $21 per M	2.95	0.50
Placing	4.83	0.81
Total	$ 9.61	$1.62
Miscellaneous:		
Platform	$ 0.92	$0.16
Superintendence	3.03	0.51
Plant	0.28	0.05
Oil	0.21	0.04
Sundry	1.06	0.18
Tools	0.24	0.04
Total	$ 5.74	$0.98
Grand total	51.62	8.75

This shaft was lined from the bottom up after excavation was completed.

Shaft Eight, Rondout Tunnel.—The description of this work immediately following that just described is interesting for several reasons. The work was done by the same firm of contracting engineers, it was done almost exactly 10 years later, and it is typical in all but one main particular of shaft lining methods on the Catskill Aqueduct Tunnels. This shaft was lined continuously, from bottom to top, while the common practice was to line in sections, as excavation progressed.

Shaft Eight was circular and 14½ ft. in diameter and 710 ft. deep. The forms, Fig. 3, were steel rings 5 ft. high, made in quadrants, trussed internally, and collapsed by pulling a key. Six rings were employed; two rings were set and concreted, then two more, and so on until all six rings were filled. Then work proceeded by pulling the two bottom rings and setting them on top. The ring quadrants were handled by means of the scaffold shown by Fig. 3, one quadrant at a time being lifted and set on top. Generally an iron ring was hoisted and erected in the 4 p. m.-midnight shift and the second ring in the midnight-8 a. m. shift. The force was 1 foreman, 6 handlers, 1 hoist runner, 1 topman, 1 pumpman and 1 electrician. Each 10-ft. height of ring was centered by plumb line from the shaft top, by measurements to the quarter points. The forms were made by the Blaw Steel Construction Co.

The concreting was performed in 10-ft. sections during the shift from 8 a. m. to 4 p. m., and working (in shaft): 1 superintendent, 1 concrete foreman, 2 spaders and 4 shovelers, and (on top) 1 concrete foreman, 10 laborers, 1 hoist runner, 1 derrick engineer, 1 mixer engineer, 1 topman, 1 pumpman and 1 electrician. The mixing and handling plant is clearly shown by Fig. 4. A 2:1:4 mixture was used and 60 4-bag batches completed a section. As the shaft had been timbered for excavation, removal of timbering was a part of the lining task; this was done in sections 50 to 100 ft. high. Including timber removal the rate of lining for the whole shaft was 5 ft. per day. The lining was somewhat hindered by dripping water from the shaft walls above.

A few comparisons of this work with other jobs of shaft lining on the Catskill Aqueduct follow: At Shaft One, Rondout Tunnel, practically the same general method was followed as at Shaft Eight, and the average rate of lining was 9 ft. per day. This shaft was dry. Concreting was done in 15 and 20-ft. sections; larger sections were found impracticable because forms could not resist the pressure.

Experience in lining these two shafts inaugurated a change in practice for all future shaft lining on the aqueduct. Timbering was dispensed with and each section of not to exceed 100 ft. sunk was lined before sinking deeper. At Shaft Six, Wallkill Tunnel, the sinking and lining was performed in 40 to 80-ft. sections. Closure joints were made, using special wooden form rings. At Shaft Sixteen, City Tunnel, it was found that the lining could be begun practically on the excavation bottom and that none but superficial injury was suffered by the concrete lining when blasting was resumed. While the hoisting plant and forms shown by Fig. 4 were peculiar to that plant alone, other shaft plants and forms were generally similar, as shown by Fig. 5.

Mine Shafts, Annabelle, W. Va.—Two shafts were lined, one circular and one oblong with curved ends. The work is instructive in the lesson it teaches in steel form design, in describing processes for making closure joints, and in illustrating procedure in form handling and concrete placing to overcome conditions of eccentricity of excavated shaft section.

The forms for the two shafts are shown by Figs. 6 and 7; they were made by the Blaw Steel Construction Co. That for the circular shaft was satisfactory in every particular, but that for the oblong shaft lacked strength due to insufficient interior bracing which had to be supplemented by 2x4-in. timbers braced from side to side. Experience here and at some of the shafts of the Catskill Aqueduct brings out strongly the need of ample provision of interior bracing for steel shaft forms. Five sets of form rings were provided for each shaft, and the details of joints, bracing, fillers and couplings are clearly shown in Figs. 6 and 7.

The lining was built alternately with excavation, nominally in 50-ft. lifts; actually this distance was varied frequently to avoid soft spots in the wall rock and to schedule the work between the two shafts in the most economical manner. In beginning a section, the muck at the bottom of the excavation was leveled and 12x12-in. timbers laid across shaft. On these timbers a narrow plank platform was built close to the shaft walls and carefully leveled. The bottom edge of the first form ring was set on this platform. Lining-up was done with levels and plumb lines.

Concrete was machine mixed at the shaft top, discharged into alternate buckets and lowered by hoist to the forms. Form rings were placed and filled successively until five had been filled, then bottom rings were pulled and placed on top until the full height of section had been lined. Two features of the concreting are instructive. Owing to irregular blasting and to rock falls, the thickness of concrete to be placed was very irregular. When a thick wall on one side came opposite a thin wall on the other side, shifting of forms toward the thinner side had to be guarded against. The method of preventing shifting was to insert on the thin wall side blocks between wall and form and then concrete this side first. The second feature was the concreting of closure joints as illustrated by Fig. 8. The method proved completely successful.

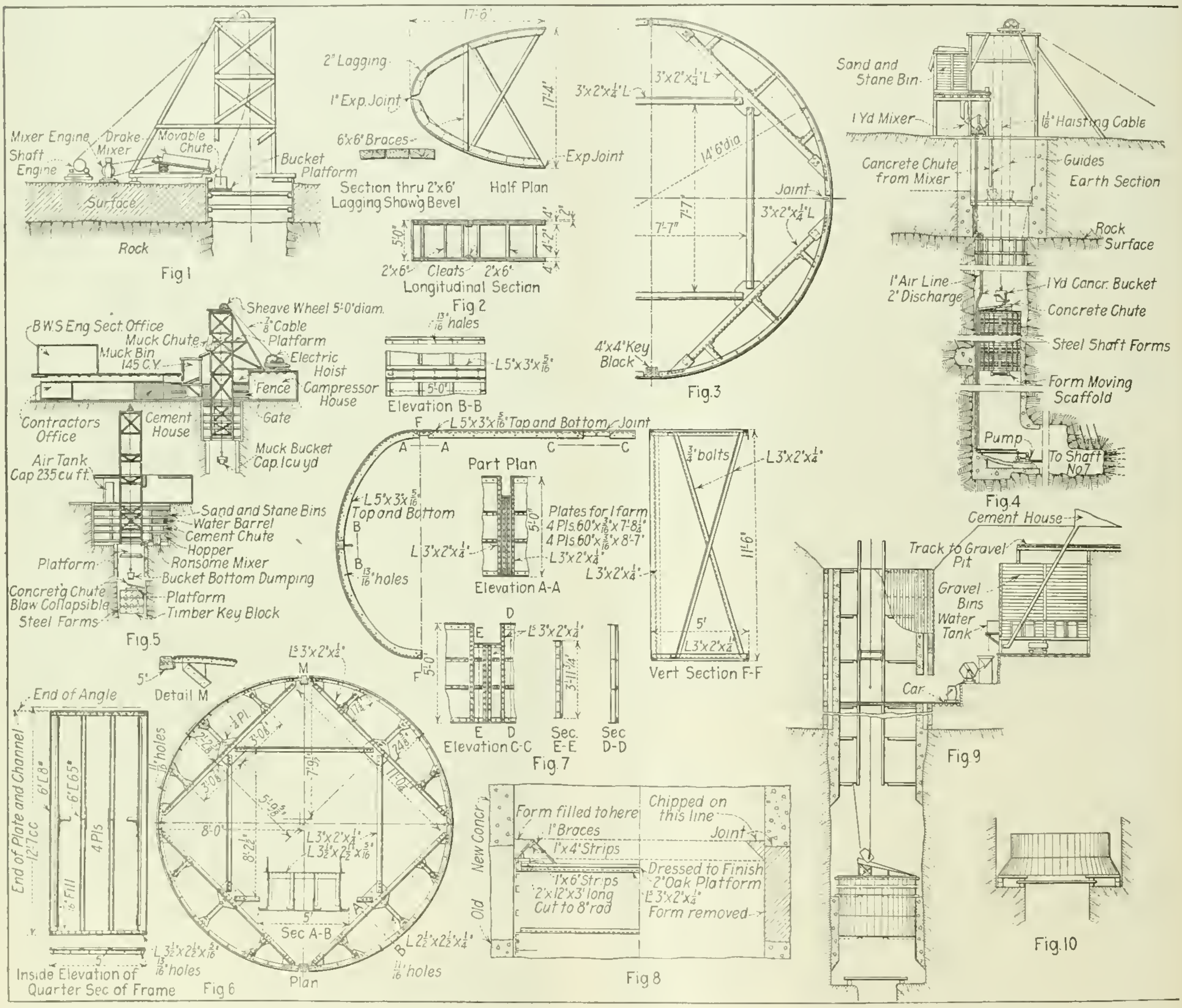
Negaunee Mine Shaft, Michigan.—The shaft was circular and 17 ft. in diameter. The work has special interest as illustrating a subsurface arrangement of mixing plant. Similar arrangements were employed at some of the shafts of the City Tunnel of the Catskill Aqueduct (Fig. 5) and greatly economized space, where space was at a premium. Another instructive feature of the Negaunee shaft work was the use of a special section starting form to bevel the lining for a closure joint at the start of such section. The shaft was excavated to circular form around a previously excavated square shaft of much smaller section as indicated in Fig. 9.

The form rings were steel and 5 ft. high, and there were four used in addition to the starting ring shown in sketch by Fig. 10. The starting ring was set first as shown and then a regular 5-ft. ring erected on it. After these rings were concreted two more rings were set. Generally two rings were concreted every second day, the alternate days being employed in erecting forms, stripping and other preparatory work. The advance was, therefore, 5 ft. of lining per day. To make the closure joint, a funnel form of steel somewhat like that shown by Fig. 8 was used, the concrete being heavily rammed into place. The general method of lowering and placing concrete is clearly shown by Fig. 9. The costs of lining this shaft are so recorded in connection with costs of other work that they are not very clear, but they are given as follows for 738 ft. of shaft:

Item.	Per lin. ft.
Excavating	$18.68
Stripping	17.33
Steel shaft frames	10.06
Steel forms	1.26
Temporary surface structures	6.74
Concrete	17.22
Compressed air	1.00
Total, less 12 ct. salvage	$72.17

Brier Hill Mine Shaft, Michigan.—The shaft is 14 ft. in diameter inside a 19-in. average lining. The procedure was by sinking and rising to open a 6x8-ft. shaft full depth, then to enlarge this to circular form, and, beginning at successively deeper levels, to place the lining working upward. Figure 11 indicates the procedure. The plant arrangement is shown in diagram by Fig. 12; the mixer was below ground, was charged by cars operating on a track system above, and discharged into buckets on a car running through a small tunnel to the shaft. In shaft the buckets were handled by hoist.

A form-ring is shown by Fig. 13; compared with the construction shown by Fig. 3 and Fig. 6 the addition of a turnbuckle arrangement to collapse the shell is noted. The rings were 5 ft. 4 in. high. In starting a section a wooden curb was built around shaft on which to seat the starting ring. Also just above the curb wooden boxes were inserted through the ring and across the lining space. These boxes left holes in the lining through which the closure joint was concreted. This is a variation from previous examples. After the starting ring, 5 ft. 4 in. high, was concreted, the procedure was to erect and concrete the rings in sets of two, 10 ft. 8 in. high. The rate of progress was two rings set and concreted and one set of shaft compartment framing placed each two days, or a progress of 5 ft. 4 in. of lining per day. Two hour shifts only were worked and the gang below ground was six men. Costs of lining are not clearly separated from other costs, but handling steel forms, concreting and placing compartment framing ran from $20 to $28 per foot of shaft. There were about 3 cu. yd. of concrete per vertical foot of lining.



FORM CONSTRUCTION AND APPLIANCES AND PLANT

Fig. 1—Hoist and Mixer Plant, Tug River Shaft. Fig. 2—Wood Form, Tug River Shaft. Fig. 3—Steel Form, Rondout Tunnel, Shaft Eight. Fig. 4—Hoist and Mixer Plant, Rondout Tunnel, Shaft Eight. Fig. 5—Hoist and Mixer Plant Typical of Catskill Aqueduct Shafts. Fig. 6—Circular Steel Form, Annabelle Mine Shaft. Fig. 7—Oblong Steel Form, Annabelle Mine Shaft. Fig. 8—Closure Joint Form, Annabelle Mine Shaft. Fig. 9—Mixer Plant and Form, Negaunee Mine Shaft. Fig. 10—Bevel Joint Form, Negaunee Mine Shaft. Fig. 11—Forms

Chapin Mine Shaft, Michigan.—This shaft was rectangular and 10x24½ ft. in sections and was 1,434 ft. deep. As shown by Fig. 14 this old shaft was lined with timber. Removal of old lining was thus a part of the concrete lining work. Also the work is distinctive from any of that previously described: (1) In the use of rectangular steel form rings; (2) in the molding, into the lining precast divider beams and end plates; (3) in the use of a novel swinging chute for concreting direct from the buckets.

The general procedure was to place the lining in sections starting down shaft and working upward to a key or closure. Thus the first section was begun 83⅓ ft. below the top and closed at the collar; the second section was begun 219⅓ ft. below and closed at elevation 83⅓ ft., and other sections of varying height followed in order. The forms were flanged steel panels with suitable notches or recesses for the ends of the concrete divider beams and end plates. A set of panels forming a 6-ft. high ring around the shaft was set up and bolted together. Next the dividers and end plates were set in place and bolted to the steel panels; these struts braced the wall forms firmly. Next the wall reinforcing was placed. The work was then ready for concreting the walls.

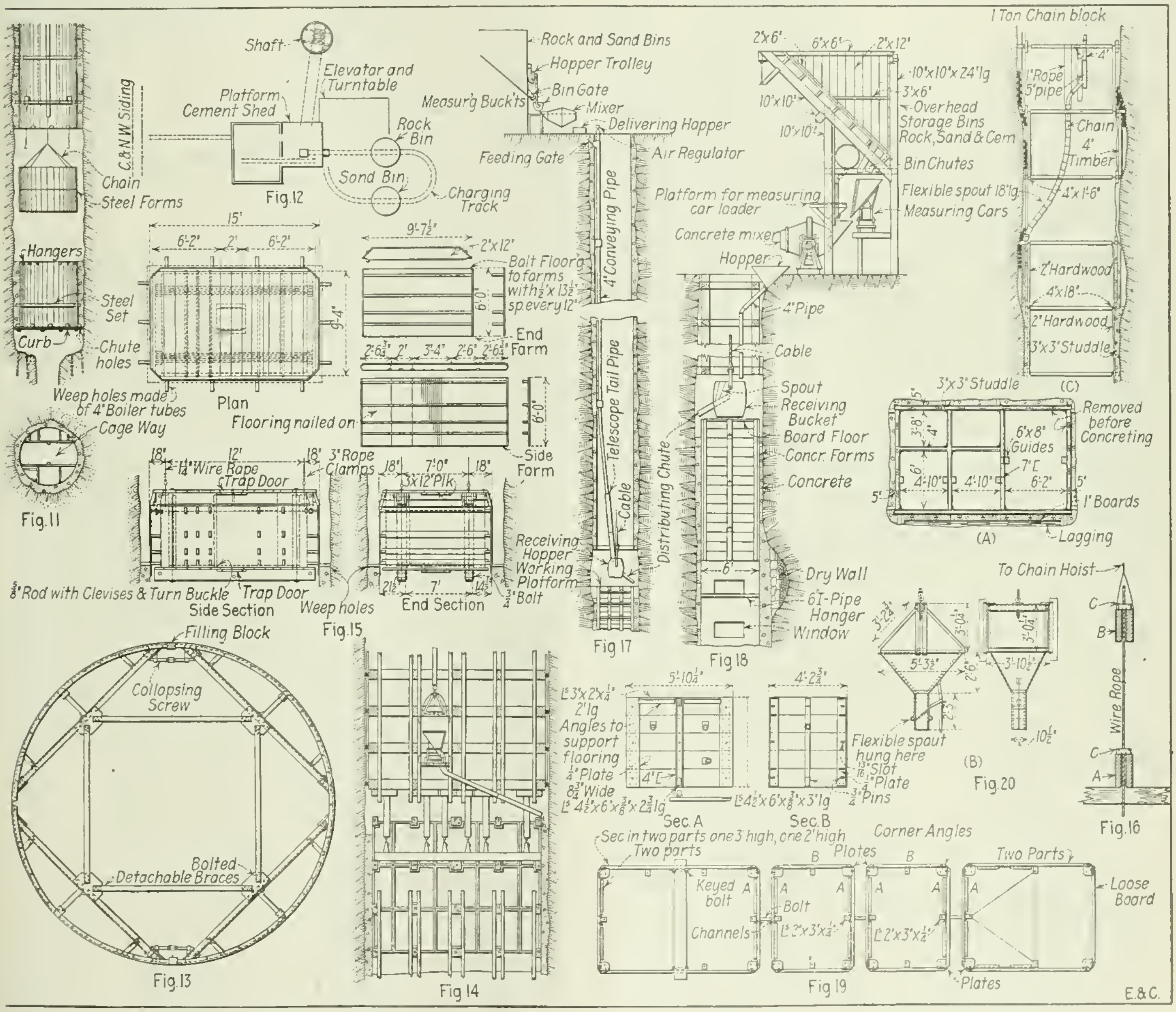
Two cages operated in the shaft. The concrete was mixed at the plant on the surface, using Smith mixers, which discharged into side dump cars. These cars were run into either cage and lowered to the work, where a revolving chute as shown by Fig. 14 was attached to car discharge spout and the concrete chuted behind the forms. All crevices in the shaft walls were packed to within 10 ins. of the forms with stone before the concrete was poured. The average amount of material for 6-ft. vertical section of shaft was 10 cu. yd. of concrete, 1 cord of stone backfilling and 550 lb. reinforcing steel. The force employed was as follows: For removing old lining, 1 man at the top and 5 men below; for placing steel forms, 2 men at the top and 4 men below; for pouring the concrete, 2 men at the top and 4 men below. Eight-hour shifts were worked and the average time required to concrete one 6-ft. section was three shifts or 24 hours, which includes placing forms, removing one set of forms and concreting.

The average rate of progress was 56.7 per month, including delays.

Dawson Mine Shaft, New Mexico.—The shaft was rectangular, 10x15 ft.; old timbering had to be removed and some trimming of knobs done. The special feature of the work was the use of suspended wooden forms handled from the head frame. The device is a suggestive one and using steel forms would seem to merit trial. The normal shaft lining was 15 to 18 ins. thick and was reinforced by horizontal and vertical ⅜-in. rods spaced 12 in. apart.

The forms are shown by Fig. 15. They were 5 ft. high, were collapsible and were hung by four wire ropes from head frame centered over shaft. The two ropes from each end of the form passed up between two 3x12-in. timbers blocked apart 2 in. and extending across shaft and made fast to head frame stringers A, Fig. 16. Above these two sets of stationary timbers were two identical sets of timbers B, hung from two chain hoists suspended from head frame. Clamps C, C, around the ropes and spanning across tops of sets of timbers held the ropes fast. To raise the form the top sets of timbers B were lowered to the stationary sets A and the top clamps shifted down to a new hold; the top sets of timbers were then raised by the chain hoists pulling up the ropes and the forms. Then the clamps over the stationary sets of timbers were replaced again, fastening the ropes. It required 15 minutes to make a 5-ft. lift and have everything ready for the next lift. The clamps were home made of ½x8-in. steel plates, a right and left plate for each clamp; plates had four corner holes for tightening bolts and in each a half round forged groove at the center to embrace the rope. Forms were collapsed for raising by removing inside braces and pulling in sides and ends. Forms caused trouble from swelling and side panels had during work to be shortened 4 ins. Also provision of corner strips for men to pry against in loosening forms would have saved forms. Forms were about completely used up when work was finished.

Concrete was mixed at shaft top and lowered by electric hoist whose line run down center of shaft and carried special steel bucket. At forms an open trough chute was connected to bucket door and concrete was spouted behind forms. Old timbers lining shaft were removed just ahead of each 5-ft. lift of form and following this the reinforcing was placed; vertical rods were 6 ft. long, leaving 1 ft. projecting above concrete for attaching next 6-ft. rods by lap joints. Horizontal rods were woven about the vertical rods. The working force consisted of 1 foreman who spent all his time in the shaft except when concrete was being placed, 3 shaft men working all the time in the shaft, 1 cement man, a man guiding bucket, 1 man handling sand, 2 men handling stone, 1 hoist man and 1 man at mixer. At times 2 extra men were required replenishing supply of stone. Working 40 days this gang concreted 34 lifts 5 ft. high and one lift 3 ft. high, five lifts being lost because of timbering troubles and loose rock.



FOR CONCRETE SHAFT LINING CONSTRUCTION.
and Form Handling, Brier Hill Mine Shaft. Fig. 12—Mixing Plant Layout, Brier Hill Mine Shaft. Fig. 13—Steel Form, Brier Hill Mine Shaft. Fig. 14—Hoist and Mixer Plant, Chapin Mine Shaft. Fig. 15—Wood Forms, Dawson Mine Shaft. Fig. 16—Tackle for Hoisting Forms, Dawson Mine Shaft. Fig. 17—Mixer Plant and Concreting Chute, Kingdon Shaft. Fig. 18—Mixer Plant, Concreting Chute and Forms, Bisbee Shaft. Fig. 19—Wood and Steel Forms, Bisbee Shaft. Fig. 20—Concrete Placing Plant, Palms Mine Shaft.

Labor cost of 540 cu. yds. of concrete in the shaft lining is summarized as follows:

Item.	Per cu. yd.
Preliminary surface work	$0.66
Securing rock and sand	1.77
Hauling cement	0.10
Movable form construction	0.281
Work in shaft	1.390
Concreting	0.891
Superintendence	0.066
Total	$5.158

Adding 46 cu. yds. of special concrete at shaft bottom, team hire and material costs, the summary becomes for 586 cu. yds. of concrete in place:

Item.	Total.	Per cu. yd.
Labor	$2,901.75	$4.95
Animal hire	372.96	0.64
Materials	2,052.64	3.50
Total	$5,327.35	$9.09

Kingdon Shaft, Globe, Ariz.—The notable feature of this work was the chuting of concrete vertically downward about 1,000 ft., and through a 4-in. pipe. The shaft was 1,017 ft. deep, and it had been previously lined with timber, which had burned out. The remaining partly burned timbers of the old lining were removed, a lining of light timbering merely to prevent rock from falling onto the workmen was built and the concreting done as indicated by the illustration. The cleaning, temporary lining, and permanent lining were performed, beginning with the top section, in six sections of 150 ft. to 220 ft. The lining was rectangular, with a center partition dividing it into two compartments, 5 ft. by 7 ft. 2 ins. each, and it was built for each section from the bottom up as indicated by Fig. 17.

The procedure in detail was as follows: Beginning at the bottom of a section, a timber set was fitted to support a form for a reinforced concrete set which was hitched onto the walls solidly as a foundation footing for the lining. A 12-ft. section of forms was next erected on the concrete set. The forms consisted of 12-in. dressed lumber nailed to a cage of 12-ft. form posts made up of a 4x4-in. post in the corner of each compartment, a 4x6 in. intermediate post on each 5-ft. side, and two 4x6-in. intermediate posts on each 7-ft. side, with 2x6-in. across compartment beams between posts every 3 ft. vertically. To allow space for the forms, two bays of temporary lining were removed. After concreting, two more bays of temporary lining were removed and another 12-ft. height of forms was placed. All forms for a full section of shaft were left standing until the entire section was concreted, then they were taken down and cleaned and used again for the succeeding sections of shaft.

The arrangement for concreting was novel and is indicated by Fig. 17. The concrete was run from mixer into a hopper and thence conducted down the shaft through a 4-in. steel pipe to an ordinary steel sinking bucket, suspended from the finished portion of the lining above, and allowed to run through a hole cut in the side of the bucket a few inches above the bottom, and through a short steel chute into the forms. This was an efficient and flexible arrangement, as the bucket could be easily swung or turned, and a continuous stream of concrete directed to any part of the forms desired. The concrete was successfully dropped in this manner for a distance of over 1,000 ft. in building the last section. The velocity of the concrete was but little greater through the pipe to the deepest part of the shaft than to the sections near the surface, provided the mixture was fed regularly and the upper end of the pipe closed at the end of each batch. This was easily done by placing a piece of canvas over the opening, stopping the air current in the pipe, thus checking the velocity of the concrete, and tending to break it up into smaller pieces, which fell with less force.

The long walls of the lining were given a minimum thickness of 10 ins. and the short walls and center wall 8 ins. Where the rock walls were very irregular, forming large concavities, large rocks brought down on the cages were thrown into the concrete. The center wall was reinforced every 18 ins. vertically with mine rails laid across the shaft in the center of the wall. The end and side walls were thus reinforced only at points where the ground was bad and at stations. The concrete was a 1:3:6 mixture of Portland cement, quartz sand, and crushed limestone from ¼-in. to 1-in. mesh. About 2,300 cu. yd. of concrete and 750 cu. yd. of large rock were used.

About 25 men were employed on the job, working two shifts. The total time consumed was eight months, of which the first month was spent in rigging up the surface plant, etc., and most of the rest of the time in cleaning down the walls and putting in temporary timbering preparatory to concreting. Also the lower 110 ft. of shaft consisted of a raise driven to one-compartment size and this had to be enlarged to full size. The actual work of concreting was done in 100 days, or about 40 per cent of the total time consumed. Ordinarily, one 12-ft. section of concrete per day was put in, but in bad ground a 6-ft. form would be used. The maximum day's work was 22 ft. The contract price was $30,000, or $28 per lineal foot.

Mine Shaft, Bisbee, Ariz.—This work is notable for the compact arrangement of concreting plant and the successful use of wooden forms. The shaft to be lined was 1,535 ft. deep and the lining replaced an old timber lining. Figure 18 explains the concreting plant fully. Two men, one at the measuring car and one at the mixer, mixed a ⅓-cu. yd. batch in 1¼ minutes.

Figure 19 shows the form construction. They consisted of rectangular rings 5 ft. high. Three complete sets of forms were used, the lowest being taken out as needed above. They were made of 2-in. timber, dressed to 1⅝-in., and fastened together with ½-in. plates. Before being put together, the boards were thoroughly soaked in water so as to be in the same conditions while making, as they would be while in use. The forms consisted of four pieces for each compartment, or more, in the case of those compartments where pipes in the shaft did not allow the handling of large pieces. In general, braces were used across the compartments between the horizontal sections of the forms. These were 2x3x¼-in. angles. They stayed the forms so that there was no bending and movement as the concrete was poured.

In No. 4 compartment, which is typical of the others, the forms consisted of two sides, marked A in Fig. 19, and the two ends B. The boards of each piece were fastened together with a 4-in. channel at the center and a ½-in. plate at each end, which was planed so as to make the pieces fit snugly together. Horizontal angles at the top reinforced the forms against buckling and also supported the boards of the working floors. As the angles were below the top of the form, these boards did not project over the curtain walls and were held in place. All four corners of the set were beveled as shown in the drawing so as to allow them to be more easily removed from the concrete. Each piece was provided with a ring at or near the upper half of the center of the form so as to permit easier handling. The four pieces were held together by a 6-in. angle iron, at each corner of the compartment. In compartment No. 1, the end was made in two pieces so to allow it to be slipped out from behind the pipes. Compartments No. 1 and 2 are really one large compartment, separated by a timber partition. Timber was used instead of concrete in order that the two compartments might be thrown into one, if desired later. In several cases, as in No. 1 and 2 compartments, a long side consisted of two pieces and these were fastened together by bolts and keys, as shown in Fig. 19. The end of No. 5 compartment consisted of loose 12-in. boards because the pipes at that end of the shaft would not permit any other arrangement. A bolt, passing through the curtain wall, held the forms of each compartment to those of the adjoining. All the form and machine work was done at the company's shops.

The method of handling concrete from mixer to form was by pipe the full depth of the work. The stone used was ⅜ to 1¾-in. and no trouble was had in passing the mixture through a 4-in. pipe. The round of operations in lining was: Concreting, removing old lining, removing and setting a ring of forms. Three shifts each of eight men and a shift boss, made up the shaft crew. Each shift completed as much of a cycle as it could and the next shift started where the preceding shift left off. The time required to remove timber, pull forms and concrete, varied

TABLE I.—COST SHEET PER FOOT AND PER CUBIC YARD FROM DECEMBER, 1912, TO AUGUST 24, 1913.

	1912.	1913							
	Dec.	Jan.	Feb.	March.	April.	May.	June.	July.	Aug.
Yardage	444.8	900.3	933.3	1,096.5	1,120.2	1,093.8	931.5	1,000.2	853.5
Footage	60	140	170	185	180	200	170	235	196
Alteration in piping, per ft	$7.84	$4.42	$4.09	$3.44	$5.45	$3.87	$4.42	$1.94	$2.35
Alteration in transmission lines, per ft	0.74	1.37	0.58	1.14	2.36	1.16	0.54	0.57	0.98
Removing shaft lumber, per ft	19.40	9.52	6.66	7.66	9.27	8.77	7.08	4.27	3.87
Waste and filling, per ft	4.37	2.88	2.57	4.09	4.41	4.68	10.75	7.11	12.06
Guides, per ft	0.14	0.32	2.35	1.49	0.00	2.74	5.33	6.57	6.07
Hoisting, per ft	29.26	12.15	10.42	10.37	9.96	9.78	20.37	6.25	7.36
(1) Repairs to concrete pipe, per ft	.....	.....	.....	0.07	0.10	0.15½	0.12½	0.01	0.00
(1) Repairs to concrete pipe, per yd	.....	.....	.....	0.01	0.017	0.03	0.03	0.00	0.00
(2) Forms, per ft	3.24	6.29	4.72	4.05	2.93½	2.15	2.25	1.60	1.85
(2) Forms, per yd	0.44	0.98	0.86	0.68	0.38	0.39	0.30	0.38	0.43
(3) Cost of concrete materials, per ft	53.83	43.52	26.00	30.31	21.33	23.68	24.93	18.50	19.66
(3) Cost of concrete materials, per yd	7.26	6.77	4.73	5.11	3.43	4.33	4.55	4.35	4.63
(4) Moving forms, per ft	27.17	16.37	11 63	10.18	8.93	8.57	8.20	7.11	7.00
(4) Moving forms, per yd	3.73	2.55	2.12	1.72	1.43½	1.57	1.50	1.67	1.65
Distributing concrete, per ft	9.20	6.64	4.06	3.17	2.77	2.25	2.73	1.90	2.50
Distributing concrete, per yd	1.24	0.92	0.66½	0.53	0.44½	0.41	0.50	0.45	0.58
Concrete totals, 1-2-3-4, per ft	93.44	72.82	46.41	47.78	36.07	36.80	38.23	29.12	31.01
Concrete totals, 1-2-3-4, per yd	12.67	11.22	8.38	8.05	5.72	6.73	6.88	6.85	7.19
Supervision, per ft	15.65	6.81	1.49	1.39	1.39	1.30	1.50	1.00	1.00
Supervision, per yd	2.11	1.06	0.27	0.24	0.24	0.14	0.27	0.24	0.23
Miscellaneous, per ft	2.08	0.67	0.47	1.45	0.52	0.84	1.69	0.73	0.62
Total, per ft	$172.92	$110.96	$75.04	$78.81	$69.43	$69.94	$89.92	$57.56	$65.32

exceedingly under the changing condition, such as the experience of the men, character of the ground, etc. When first started, the work required as much as two shifts to pull forms, while later on, the average time was five hours. During the months from February to June, it required an average of about 20 hours to complete the cycle, the time being distributed approximately as follows: Removing shaft timbers, 5 hours; removing waste or backfilling, 4 hours; pulling forms, lining and blocking, 8 hours; concreting, 3 hours. For the upper 450 ft., the average time required for a cycle was 12½ hours with an approximate distribution of time as follows: Removing timber, 2 hours; drilling and shoveling, 4 hours; pulling forms, lining and blocking, 5 hours; concreting, 1½ hours. For this instance, the walls had to be blasted all around an average of 8 ins., making about 25 cars per 5 ft. of shaft.

The costs of this work are recorded in much more detail than is common and as an example are given in Table I.

Palms Mine Shaft, Bessemer, Mich.—The shaft was rectangular and was lined for a depth of 1,170 ft. Concrete was mixed on the surface and was deposited (1) for concreting isolated sets during excavation by means of the hopper bucket B, Fig. 20; (2) for concrete lining proper by means of the apparatus shown at C, Fig. 20, and described as follows: The concrete was mixed in the proportions of 1:3:4 in a ½-cu. yd. electric driven mixer, and conducted through a launder to a 4-in. flanged pipe laid from surface. The lower end of the 4-in. pipe telescoped into a 5-in. branch. This 5-in. branch took the blow of the concrete. To the bottom of the branch was connected a reverse bend with its lower end vertical. A flexible spout 18 ft. long which fitted over this conducted the concrete to the forms.

While the concreting force was filling one set, other men were removing the blocking from the set above, hanging the strands of old wire rope vertically 1 ft. apart and horizontally about 3 ft. apart for reinforcement, and placing the forms. For an 8-ft. span, 2-in. hardwood plank was used, and for 4-ft. and 6-ft. spans 1⅝-in. hardwood plank. The plank was cut on a bevel on the upper end, so that the concrete came underneath the steel sets for a support. The bottom end came tight against the outside flange of the H-section. Two-inch strips of wood about 12 ins. long were laid 1 in. apart between the bottom end of the plank and the inside flange of steel. When these strips were taken out the planks were easily removed from the concrete.

The concreting required the 10 miners for removing lagging, placing reinforcement and placing plank forms. The four timbermen attended to the distribution of the concrete to the forms. On surface three men wheeled rock to the mixer, two men the sand and cement, one poured water and attended to the securing of the proper mixture, one discharged the mixer, one looked after the launder from the mixer to the 4-in. pipe and two men conducted the concrete down the 4-in. pipe. All the men worked 8-hour shifts on the concreting. The rate of progress lining was 35 to 48 ft. per day. Data reported by Frank Blackwood, chief engineer.

Discussion.

The examples given have been selected for two main objects: (1) to illustrate form construction and form handling methods; (2) to illustrate concrete plant arrangement and methods of handling concrete from mixers to forms. Within these two subjects are comprehended all the features that differentiate concrete shaft lining from concreting for any other purpose.

Form Construction.—Lining shaft is lining tunnel set on end. Substantial invariability of section prevails the full length of lining. The first thought in form construction for shaft lining as in form construction for tunnel lining is repeated use of the same form. A form material which resists wear, a form construction which maintains shape and dimensions, and a form assembly which facilitates mobility are essentials. The two materials used in concrete form construction are steel and wood and a study, based on the examples cited, of how well each meets the three essentials named is the first task.

Theoretically the two materials compare as follows: In resistance to abusive wear steel excels wood. It is harder and its texture is not weakened by absorbed water or leachings from the concrete. Steel does not swell, shrink or warp due to drying or wetting as does wood, and forms of steel retain shape and dimensions better than do wood forms. Steel or wood forms are either one readily made in sections capable of easy assembly and moving. Steel, however, retains its shape and dimensions and suffers no decrease in ease of assembly as time goes on, while wood by swelling or warping due to moisture is likely to grow constantly more difficult to assemble. Wear of joint parts and bolt holes is less in steel than in wood. Steel forms generally pull more easily than wood which is another advantage. In weight of parts to be handled there is very little if any advantage on the part of either material. Epitomized, a steel form unit is more desirable than is a given unit of wood. In this statement durability means not only resistance to abrading wear but persistence in shape and dimensions.

Analyzing the forms illustrated a number of interesting facts appear. Circular form construction as shown by Figs. 3, 6 and 13, has been substantially standard in adopting the quadrant as the movable section unit, in the arrangement and character of interior bracing; in the shell construction and in the key block arrangement for collapsing and assembling the ring units. Rectangular form construction shows no such uniformity. Both steel and wood claim place as a form material, but wood is more favored. Considering rectilinear forms of steel as illustrated by Figs. 7 and 14, one was defective due to insufficient interior bracing and the other, Fig. 14, was an unqualified success due to a most thorough means of bracing provided by the precast dividers and end plates. Three rectangular wooden forms are illustrated by Figs. 15, 19 and 20. Experience with the first, Fig. 15, illustrates the typical, possible weaknesses of wood as a form material in lining shafts. This form of substantially all wood construction deteriorated quickly through wear, but more particularly through swelling which made necessary repeated cutting down, and through injury in pulling. In the case of the form shown by Fig. 19, a notably good record of endurance was exhibited, and a brief examination shows why this was so. The frameworks of the form panels were steel angles, channels and plates—only the skins were wood. The steel framing itself suffered no distortion due to swelling and was rigid enough to restrain any distortion tending to be induced by the swelling wooden skin. In Fig. 2 is shown the only wood form of curvilinear section represented by the examples cited; it was successful and endured in good condition the life of the lining work. At the time of its use, 1903, steel as a form material had not been generally accepted; today, one feels almost safe in asserting, a steel form would be used. The other example of wooden forming, at Globe, Ariz., may hardly be classed as a movable unit-panel construction. Practically a stationary forming was built up in 12-ft. tiers or stories, then after several had been concreted, the bottom story was dismantled and rebuilt again on top. At the Palms mine shaft the forms were separate plank held against the steel shaft sets.

Summarized, steel forms were used in all the shafts cited in the examples given except in five shafts. A tabulation brings out this fact as follows:

Shaft.	Section.	Material.
Tug River	Elliptical	Wood
Rondout	Circular	Steel
Annabelle (air)	Circular	Steel
Palmer	Rectangular	Wood
Negaunee	Circular	Steel
Brier Hill	Circular	Steel
Chapin	Rectangular	Steel
Dawson	Rectangular	Wood
Kingdon	Rectangular	Wood
Bisbee	Rectangular	Wood

This tabulation alone presents ample reason for concluding that steel forms for shaft lining are the rules of practice and wood forms are the exception. In a sense, however, the tabulation is not fairly representative. One typical example only is given of shaft form construction on the Catskill aqueduct. Of the upward of 30 lined shafts in the aqueduct all were circular and all were lined using steel forms.

Mixer Plant Location.—The volume of concrete required in shaft lining is in no case large and the speed at which it is placed is not great. In size then mixing plants for shaft lining are not notable. Plant location is almost invariably at the shaft head and in shaft head location there are only two variations. The mixer, in one is located on the surface as shown by Figs. 1, 17 and 18; in the other the mixer is set below surface as illustrated by Figs. 4, 5 and 9. Gravity arrangements are practically universal. The drawings leave little else that requires to be noted.

Concrete Handling.—Methods of conveying concrete from mixer to forms are broadly divisible into (1) lowering in buckets operated by hoists, (2) chuting by pipe reaching from mixer to forms. The first method is, perhaps, again logically divisible into two; in one the bucket is dumped onto a shoveling platform at form top level and in the other the bucket is discharged into a chute emptying behind the forms. Examples of the first main division are shown by Figs. 1, 4, 5, 9, 11 and 14 and of the second main division by Figs. 17, 19 and 20. The most distinctive example of bucket discharge into chute is shown by Fig. 14. Figures 4, 5 and 9 show also bucket discharge into chutes, but in these examples the chutes are such scarcely so much as inclined shoveling platforms.

Notably good practice in concrete handling by buckets is exemplified by the Catskill aqueduct work as represented by Figs. 4 and 5. A bucket charging platform with trap doors completely closes the shaft top. The hoists having also to serve for excavating the shafts are quick acting and high powered. Bottom dumping concrete buckets are employed. Very rapid lining was accomplished by these plants. In cases, as shown by Fig. 14, when buckets discharging by chute directly into the forms have been employed, the bucket has been provided with a special discharge spout or door which connects with or fits the chute hopper.

Conveying concrete from mixer to forms by vertical pipes is a recent development and is recorded by only three examples, Figs. 17, 18 and 20. The records are unique (1) because of the great depths, upward of 1,000 ft. in all three instances, of vertical chuting and (2) because of the small diameter of pipe, 4 ins. in all three shafts, which was successfully used. In general the spouting methods at all three shafts were similar. Perhaps the most simple arrangement of the three is that shown by Fig. 18. At the top the spout had a hopper; at the bottom it discharged into a separately supported bucket which received the shock of the falling concrete, furnished a small reservoir, and changed the speed of flow. In Fig. 17 the bucket arrangement at the spout bottom is almost identical with that shown by Fig. 18; at the top the concrete entered by a branch in the vertical spout. This arrangement permitted regulation, by closing or opening the spout top, of the speed of drop of concrete in the pipe. In Fig. 20 a variation in spout bottom arrangement is shown. A branched pipe of larger diameter than the spout proper was employed instead of the buckets shown in Figs. 17 and 18, to take the shock and change the speed of discharge; also use was made of a flexible concreting spout.

Speed of Lining.—The speed with which concrete shaft lining can be constructed is an individual quantity for each shaft. Whether lining is continuous or alternates with excavation, whether or not timber removal and trimming are required, or compartment framing has to be set, or seepage must be handled or other influencing conditions exist, all affect speed. In the following tabulation there is given as closely as the records permit determination the speed of lining a number of shafts:

Shaft.	Size, feet.	Speed.
Tug River	Ellipse, 17⅓x35	5 ft.
Rondout, No. 8	Circle, 14½	5 ft.
Negaunee	Circle, 17	5 ft.
Brier Hill	Circle, 14	5⅓ ft.
Chapin	Rect., 10x24½	6 ft.
Dawson	Rect., 10x16	5 ft.
Kingdon	Rect., 10x15	12 ft.
Bisbee	Rect., 6x27¼	5 ft.
Palms	Rect., 10x16	35-48 ft.
Rondout, No. 1	Circle, 14½	7½ ft.

At City Tunnel Shaft No. 16, for the Catskill aqueduct, lining was placed at the rate of 15 to 20 ft. per day. Another statement referring to all shafts of this tunnel states that the lining of a 100-ft. section in 16 to 17 days was ordinary progress and often this speed was doubled. Their shapes were all 14 ft. in diameter.

These figures of speed are not comparable; the number of men and number of shifts worked varied, as did other conditions.

Lining Costs.—Costs of concrete shaft lining have been very seldom recorded. This is because usually they are lumped with costs of sinking or other operations. In the preceding examples all available costs have been given, and in particular our excellent tabulation of costs is set down. The writer is disposed to think that the range of monthly costs in this table is very closely the range of costs in shaft lining generally.

Lessons of Catskill Aqueduct Shafts.—Only one example is given from the Catskill aqueduct of shaft lining methods in detail, but incidental reference has been made to other examples. Altogether there were upward of 30 lined shafts on this work, all circular in sections and all lined with concrete. This extensive shaft construction has demonstrated a number of things. Perhaps the greatest has been a determination beyond dispute of the practicability of rapidly sinking and lining circular shafts. This was a fact not admitted by American engineers when the aqueduct work was begun. In the particular line of work being considered the aqueduct work has demonstrated that by alternate sinking and concrete lining it is possible to excavate and line a shaft nearly as fast as it can be excavated and timbered.

The third annual meeting of the Florida Drainage Association will be held at Sanford, Florida, Feb. 28, 29, 1916. The question of land reclamation for agricultural and other purposes will be discussed by engineers, contractors, business men, lawyers and scientists. Exhibition of ditching, leveeing, pumping machinery, etc., is invited.

Engineering and Contracting

Devoted to the Economics of Civil Engineering Design and to Methods and Cost of Construction

EDITORS

H. P. Gillette C. S. Hill C. T. Murray S. C. Hadden C. W. Malcolm

Volume XLV. CHICAGO, ILL., FEBRUARY 16, 1916. Number 7.

FREE PUBLICATION OF ADVERTISEMENTS OF VACANT POSITIONS.

The publishers of Engineering and Contracting have decided to undertake the publication of advertisements of vacant engineering positions without charge to the advertiser. This plan will be given a thorough trial; whether it is continued indefinitely or not will depend on how the engineering public receives it.

There has been much talk of late about cooperation between engineers. Much of this has related to the bringing together of those who have engineering positions to fill and those who wish to secure such positions. We are undertaking the plan here announced in furtherence of that kind of cooperation.

While engineering work is beginning strongly to feel the general business revival, there doubtless are many capable engineers still unemployed. Many others are simply filling in, by holding a position which pays a living salary, while waiting for something more attractive to turn up. These considerations, coupled with the firm conviction that construction activities will soon be normal, and considerably above the normal of recent years, prompt us to extend our good offices in the manner outlined.

The success of this plan will depend wholly on the attitude of employers toward it. We urge such men to join us in giving it a good trial. We understand the limitations of such brief advertisements as we plan to publish and we also understand their strong points. That they are well worth while is the only conclusion which can fairly be drawn from the fact that they have long been published, in limited numbers, at space rates in this and other journals of like character.

The advertisement should be concisely and clearly written, containing such information as the applicant will naturally want. The employer's name and address may be published with the advertisement, or a key number will be supplied in this office, and the employer's name withheld from publication, on request. In the latter case we shall forward all letters received in reply to an advertisement to the person who requested its insertion. For this service there will be no charge.

The publishers will find much pleasure and satisfaction in performing this service and hope advantage will be taken of the offer here made.

AN OPPORTUNITY TO FURTHER COOPERATION AMONG ENGINEERS.

Twelve years ago the American Society of Civil Engineers declined invitation to share in the Engineering Society Building and to become a part of the United Engineering Society. Recently this invitation has been repeated and acceptance can be made on remarkably favorable terms. Whether or not the original refusal was wise is now interesting merely as history. The present action asked for must be decided solely upon the logic of conditions as they now exist. To most members perhaps the action to be decided upon will seem to be determined by the answers they make themselves to two questions: (1) Will the Civil Engineering Society suffer financially by making the change? (2) Will the society suffer in individuality and prestige by making the change? One cannot see how material loss of either kind can occur. Leaving argument on this question to others or to a future occasion, it is proposed to consider here not the chances of loss in money or fame, but the opportunity offered for gain in usefulness to the engineering profession.

There is a wide feeling of discontent among engineers. This is being witnessed in various ways. One bears complaint of meagre compensation, another of irregular employment, another of interference of politics, another of public disregard. A score of ways are proposed for eradicating or counteracting each or all of these evils and all ways have their disciples and their non-believers. From all this tangle of ideas and plans one idea, education of the public to appreciation of engineering direction, and one plan, cooperation of engineers in teaching the public, have begun to stand forth as rallying points for all sects and doctrines. With the joining of the American Society of Civil Engineers to the national societies of mining, of mechanical and of electrical engineers there will be available for cooperative effort a body of 30,000 engineers in a United Engineering Society.

Will this United Association of Engineers commit itself to broad cooperative work? Scepticism concerning this prevails. One of the strongest facts urged in recent years in support of independent organizations for general betterment of the engineers' public position has been that the great national engineering societies refused to recognize any obligation to act. There has been justification for this feeling. There is still justification for it. But there is much less justification now than there was once. Strong encouragement in this assertion is found in the circular just published by the Board of Direction of the American Society of Civil Engineers and presenting the case of the Society in respect to its partnership in the United Engineering Society. It is stated: "The engineering profession needs cooperation along these lines, there being no coherence between individuals, or groups of individuals, and it is one of the purposes of this movement to strengthen the bonds of brotherhood which should exist between all engineers." But aside from this official confession of new faith there is the far more important fact that within the membership there has grown a strong sentiment that close cooperation and concerted action is needed in matters of general welfare of engineers, and this development continued will bring a policy of cooperation, despite all precedent in opposition.

There are, we believe, other good reasons why the American Society of Civil Engineers should affiliate itself with the other society units of the United Engineering Society, but in the opportunity it gives for cooperative work for general professional welfare there is alone ample reason. Engineering and Contracting hopes sincerely that the letter ballots now being received will show a strong majority in favor of membership in the United Engineering Society and of partnership in the Engineering Societies Building.

SCIENCE IN EXCAVATING.

Digging "dirt" and blasting rock are commonly regarded as arts not reducible to scientific rules. In a limited sense this conception is true, but, if science is classified or systematized knowledge, it must be conceded that even excavation can be studied as a scientific problem.

There is, for every excavation job, some one combination of men and machines that will effect the minimum cost per cubic yard. The problem in economics is exceedingly complex, for there are innumerable possible combinations of men and machines. From this myriad of ways and means some one must be selected. Usually the selection is determined by "hunch," or, as the psychologist would say, by subconscious intuition. Often the selection is left entirely to a foreman, who may be a very efficient man driver but a relatively poor analyst of costs.

The first step in a scientific study of excavation is the installation of a system of unit cost keeping. The second step is the periodic analysis of the time required for the various operations involved in excavating, as determined by "time studies." These two methods of collecting quantitative facts about your own particular excavating jobs should be supplemented by a study of the literature on excavating and transporting materials. Books, articles and catalogs should be secured and read—and re-read.

Pertinent facts having thus been gathered, the final step is to be taken, namely the selection of the most economic method for the case in hand.

Due to the complexity of the problem it is usually desirable to determine by trial or experiment what method is preferable, after the choice has been "boiled down" to a few methods. Yet how seldom is this done even on large jobs where it would pay best to experiment. Science, be it remembered, advances mainly by experimentation. Excavation can never be classed as scientific until experiments are made and quantitative records derived by trial.

Often a day's trial, in which times and costs are ascertained in detail, will disclose which of two or three methods is preferable. Of course in making tests of a new method, or one that is new to the men, it should be remembered that skill is acquired only by repetition, and, therefore, that a short-time test of a new device or a new way of using an old device may not be a fair test. But there are many methods involving nothing particularly new in each of the several processes, the newness consisting solely in a novel combination of old processes. Then a short-time test is apt to be as conclusive as a long-time test.

Record, read, experiment, analyze the data quantitatively and you will soon find that the science of excavation is vastly more effective than the art of excavation. Science moves by proof. Art moves by "hunches."

DRAINAGE ENGINEERING IN MICHIGAN.

A new drainage law is urged for the state of Michigan in a report recently made after a careful study of drainage conditions in that state by engineers of the U. S. Department of Agriculture. As in many other states, indeed as in most states until within very recent times, legislation governing drainage in Michigan is a patchwork made from pieces of drainage laws dating back into the early years of the last century. The report mentioned notes this fact and observes the conditions that have resulted. To rehearse these conditions is ink wasted; every drainage engineer reader of the middle western states can visualize them perfectly from his own experience. But there are facts brought out in the report to which repetition can always and pertinently be given. They are the low status and the low pay of the drainage official—in Michigan the drainage engineer and the county drain commissioner.

The drain commissioner in Michigan is the chief county official having direction of drainage work. The salary paid him is too small in every county for the duties and responsibilities of the position and in some counties it is so small that the commissioner must to live work and collect wages as helper on the surveys of the drains. And the position is elective. The election is for two years. Admitting that county politics chances upon the choice of an able man, he can just learn his duties well in two years. Then the political whirligig more often than not turns the trained man out and puts a new and untrained man into his place. So much for the county drain commissioner. The drainage engineer has no official status. As matters go he is ordinarily only a man hired to "set stakes" and "run lines" to suit the ideas of the landowners.

The preceding statements exaggerate nothing. In fact they moderate the assertions of the report. They are not true, of course, of all drainage engineers nor of all drain commissioners. They are not reported here as aspersions on Michigan particularly. Their importance is in the fact that they exemplify in general the popular ignorance of any considerable requirement in drainage work for trained engineering skill. A very great need exists in almost every state of a true knowledge of both principles and technicalities of drainage work. For Michigan the report being considered recommends among other things a State Drainage Engineer. The argument from the report is published on another page. One phase of this argument, namely the educational value which lies in such an office suitably directed, deserves particular consideration. This value is large. There is sound precedent for this assertion.

Popular understanding of the economy of improved highways has increased many fold in ten years. This has resulted from many causes, but no one cause has contributed more than the intelligent promotion work of state highway engineering departments. In like manner a state drainage department directed on the same high plane as are our better state highway commissions could do a wonderful work in advancing better practice in drainage work.

EDITORIAL COMMENTS.

Inscribed on the library wall of the Engineering Societies Building is this definition, "Engineering: The art of organizing and directing men and of controlling the forces of nature for the benefit of the human race." Twenty years ago such a definition would scarcely have found acceptance. Today the engineer aspires, as a rule, to be an executive. This definition voices the aspiration.

The editor frequently visits the library just mentioned, but never ceases to be astonished at the loneliness of the place. The fault lies not with the library, for it has 65,000 technical volumes, and 1,000 current periodicals are in its files. Do engineers cease to be students after graduation? Or is it New York City that lures men from the lamps of knowledge to the lights of gayety?

And while we are on this thought it is perhaps not worthless to inquire how many persons if asked would classify reading among the habits. Yet what else has the persistent reader which the non-reader does not have but the set habit of reading? Commonly he has no more and often he has less leisure. Reading has simply become a habit with him. Lack of time keeps no man from reading, but want of the habit of reading keeps many men from reading—and engineers are no exception.

"Men are creatures of habit." A trip across the continent should drive this old saw deep into the most blockheaded observer. On the Pacific slope one sees nearly every grading contractor using fresno scrapers, gang plows, and multiple mule teams, handled with jerk lines by a "skinner." On the Atlantic slope, for the same class of work, ones sees wheelers and slips, one-share plows and horses handled in single spans by one driver. You may write to, talk to, and motion picture to an Atlantic coast contractor that he is losing money by not adopting Pacific coast methods of grading, but "habit" has locked him in a cell and lost the key.

Habit is a gaoler who respects no class of persons. Engineers are quite as strongly imprisoned by habit as are contractors. A generation ago civil engineers in Washington and Oregon used timber for almost every sort of structure. Timber being cheap its use became a habit. Even roads were built of plank and often laid on gravel soil that needed only a little rolling to be made into an excellent road surface. Conversely, eastern engineers used steel to an extreme, because the habit of building for "permanency" was prevalent. Yet nearly all the "permanent" steel railway bridges built 20 or 25 years ago have been scrapped. Heavier rolling stock brought their eternal lives to a mortal end, without leaving even a "Hic Jacet" to mark their final place of rest.

A clergyman's opinion on the public duty of engineers has the value of rarity. Also it seems incongruous for the cleric to have pertinent opinion on such a subject. The quotation that follows is therefore interesting.

> Formerly the engineer's work had to do more with what I shall call the extension phases of community life. That is, he was essentially a surveyor, a builder of roads, one who went before us and laid out the land, so to speak. Increasingly his work will be what I might call intensive; that is, increasing in its degree of application to the city, the state, the nation and the world. Just as in former times he went before or with the pioneer and laid out the land which was to be possessed, so now he goes before or with the community and makes truly available and livable the land which has been possessed but only partially conquered and subdued. Increasingly the engineer's problems will be community problems. And since that is true you ought to be increasingly students of such problems and participate actively in their solution. No longer should you dwell apart as mere specialists to be called out on occasion for the solution of some special problem given or pointed out to you by the individual or the community. You must, on the contrary, in all legitimate ways give to the community increasingly the advantage of your knowledge and skill.

Evidently few engineers are closer to the best recent thought of engineers on public duty of the profession than is the Rev. James Robert Smith of St. Paul, Minn.

Again comes a cry from St. Paul. This time it is President Geo. H. Herrold of the Civil Engineers' Society of St. Paul who utters it. He says:

> I have heard somewhere that the average engineer has the art of self-abnegation reduced to a science. This is an exaggeration, but it may be a near-truth. This quality is one which cannot be considered a virtue in the business world of today, and, while I would not advocate that other extreme as expressed by that grand old philosopher, Confucius, "He who toots not his own horn, his horn will not be tooted," I believe that there is a happy middle ground on which the professional engineer may stand within ethical bounds and make known his talents to the uneducated public.

Incidentally Mr. Herrold and the St. Paul Society are doing some forceful work toward eradicating public uneducation concerning the work of the engineer.

A year's work of a state highway commission is summarized very briefly in another column. Speaking precisely the summary includes only the engineering work of the commission. Attention is here directed to this record of labor accomplished, not because we consider the Hawkeye state to be alone possessed of hard working road commissioners but because it not unfairly indicates what good highway commissions are doing all through the county. And the cost of this commission has been less than one cent for each dollar's worth of work directed—engineering insurance on public works is exceedingly inexpensive if the public would but realize it.

Engineers head the list of notable Frenchmen who have died "pour la Patrie" in the present great war. The "roll call," as it is defined, of 3,084 names notable in literature, science, art, politics and the professions, includes 113 civil engineers. Next comes 110 lawyers dead. And all other professions named fall far behind these two in length of their lists of killed. Modern war is the sublimated employment of engineering for distruction. So far as pride can come to one because of success in and sacrifice for such a purpose the engineer claims it justly.

Clifford Thorne, avowed advocate of minimum railway rates although holder of a supposedly judicial position as a public service commissioner, now attacks Louis D. Brandeis, the man who made "scientific management" famous by declaring that, if applied to railways, "scientific management" would cause a saving of $1,000,000 a day. Thorne says that Brandeis is unfit for the Supreme Court because Brandeis once said that railway stock should be allowed to earn 7.5 per cent. Presumably Brandeis would be an admirable Supreme Court justice had he once remarked that 3.5 per cent is an adequate return for any railway.

METHOD OF CONSTRUCTING SAND AND OIL ROADS BY THE LAYER METHOD.*

By W. R. Farrington, Division Engineer, Massachusetts Highway Commission.

In constructing a road by the layer method, the subgrade is shaped and any sandy places hardened. Either 1½ gal. of hot oil in two applications, or 2 gal. in three applications, are put on. Sand is spread over the oil after each application, and the road rolled with a horse roller, it being well to do the final rolling with a steam roller, if one is available.

With the ¾-gal. application of oil, about 1½ in. of sand are used for covering; and with the ⅔-gal. application, about 1¼ in. The 1½-gal. treatment should give eventually a thickness of about 3½ in., and the 2-gal. treatment, about 4 in.

If it is desired to confine to one season all work on the road properly chargeable to construction, 2 gal. of oil should be used, otherwise it is advisable to use only 1½ gal. the first season and to apply another ½ gal. the following spring. Experience has demonstrated that any surface constructed of sand and oil by the layer method will be more or less out of shape for some time after the oil is applied, and that weak places will develop. It is principally for this reason that it is more satisfactory and economical to delay the application of the last ½ gal. of oil until the second season. By this method it is possible to find and strengthen any weak places and to remove any inequalities in the surface by scraping with a road machine before the final application of oil.

The heavier grades of oil used for hot blankets are suitable for sand and oil layer work. Some oils with a viscosity as low as 200 seconds, and others with a viscosity of 845 seconds, have given good results, but usually an oil having a viscosity of from 500 to 600 seconds will give the best results. The specific gravity should be between .98 and 1.00 at 25 degrees C.

A clean, sharp and fairly coarse sand will give the best results, but a comparatively fine sand, even one containing a small proportion of clay or loam, will give good results with the proper grade of oil. Tests made of the sand used on layer work in various places show that the finest sand was such that 24 per cent passed a 50-mesh screen and only 4 per cent was retained on an 8-mesh screen, whereas of the coarsest sand 12 per cent was retained on an 8-mesh screen and only 18 per cent passed a 50-mesh screen.

The oil should be applied by a distributor which will spread it evenly over the surface. The best results are obtained by the use of a pressure distributor, and usually a horse-drawn machine is preferable to a motor truck, since the ordinary subgrade will not carry a truck without rutting and breaking up. The oil should be shipped and heated in tank cars, but it is advisable to have the distributor carts equipped with steam coils or oil burners, so the oil can be heated in the carts if necessary.

For hardening the subgrade, sandy loam or clay is ordinarily used, 2 or 3 in. of either material being sufficient to carry the travel while the surface is being formed. Gravel is preferable, as this will add strength to the surface, but suitable gravel is usually not obtainable in those sections where the sand and oil roads have been constructed by the layer method, and if it is obtainable it is probably advisable to substitute bituminous gravel for the sand and oil.

The surface of a sand and oil road constructed by the layer method should have a crown of not over ½ in. to the foot, and should be at least 15 ft. wide; from 16 ft. to 18 ft. is a more satisfactory width unless the shoulders are hardened, as, if there is any considerable amount of turning out on to soft shoulders, the edges of the sand and oil will be broken down rapidly.

The cost of the surface of sand and oil roads constructed by the layer method has varied from 21 ct. to 33 ct. per square yard, the average cost being 26 ct. per square yard. This cost does not include grading, culvert work, etc., but does include shaping the subgrade. The average yearly cost of maintenance of the first section constructed has been 2 ct. per square yard, and of other roads constructed at least five years, 1 ct. per square yard.

---

*Extract from a paper read before the Boston Society of Civil Engineers.

SOME FEATURES OF THE NEW DULUTH PLANT OF THE MINNESOTA STEEL CO.*

The new plant of the Minnesota Steel Co., a subsidiary of the United States Steel Corporation, at Duluth, Minn., possesses a number of interesting features and is a good example of an efficient, modern steel-making plant. Briefly the plant compresses coke ovens having a daily capacity of 1,000 tons; a by-product recovery plant; two blast furnaces rated at 500 tons each; a gas-engine-driven blower and electric generating station; an open-hearth plant with ten 75-ton furnaces, of which seven are completed; a combination rail, structural, billet and bar mill; and a merchant mill. The estimated capacity of the works is 350,000 tons of semi-finished and finished steel products. The first iron was produced on Dec. 1, 1915, and the first steel on Dec. 13.

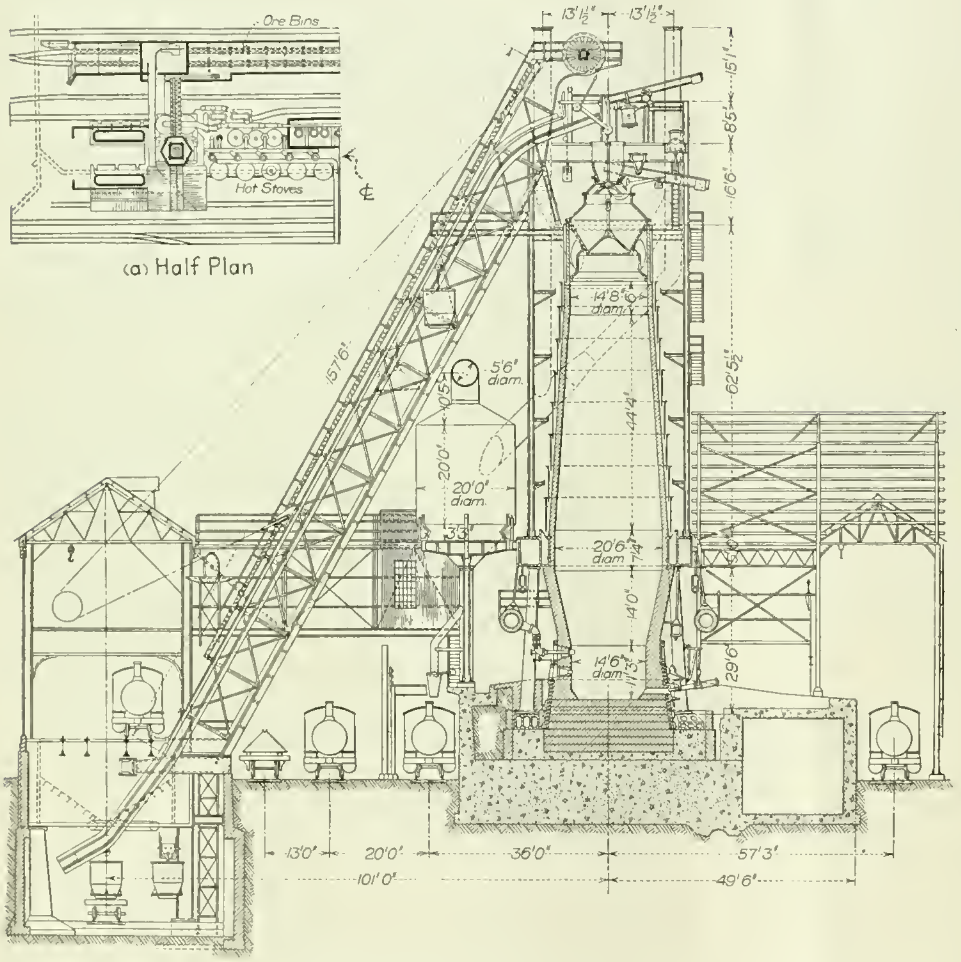


Fig. 1—Half Plan and Sectional Elevations of Blast Furnace, Stock House and Skip Hoist of Duluth Plant of Minnesota Steel Co.

The distinctive characteristics of the plant are the massiveness of its construction throughout, and the details which have been incorporated as precautionary measures against the severe weather conditions of the Duluth winter. The two principal problems in connection with which new experiences are likely to be encountered are the operation of the blast furnace at the extremely low winter temperatures, and the flexibility of the rail and structural mill in producing economically the variety of products for which the rolling mill was designed.

The Blast Furnaces.

The two blast furnaces are located on 360-ft. centers, with five stoves for each furnace, spaced 28 ft. 3 in. on centers. The stacks have a rated capacity of 500 tons each and are 89 ft. high and 20 ft. 6 in. in largest inside diameter (see Fig. 1). The hearth has a diameter of 14 ft. 6 in., which gives the boshes an inclination of 77½°. The furnace shell has a 16-in. lining and is water cooled, with a series of eight troughs, having an aggregate water space of 2,087 cu. ft. The water space in the mantel is 805 cu. ft. The top section of the stack, in which the bells are mounted, is a cast iron ring 6 in. thick, water cooled with 1½-in. pipe, 12 ft. high and made in eight section. The large bell has a maximum diameter of 9 ft. The furnaces have two cinder notches 120° apart and 30° off the center line of the furnace. For each stack there are two concrete cinder-granulating pits, each of 15,000 cu. ft. capacity, one for each notch, spanned by an overhead crane. Each stack is carried on six cast iron columns, placed on a circle of 30 ft. diameter at the top and 33 ft. at the bottom. There are twelve tuyeres, two between each pair of columns.

The furnaces are equipped with the Neeland charging system and top, the latter being similar to the Duquesne furnace tops. The top of the skipway is supported on the framework which incloses the furnace, this framework serving also as a support for the corrugated sheeting within which the stack is entirely inclosed. The skipway is inclined at an angle of 61° from the horizontal, and the charging buckets have a charging capacity of approximately 16,000 lb. of ore and about 11,000 lb. of limestone. They have a total cubical capacity of 197 cu. ft. The bell-operating mechanism is on top of the stack with the control in the hoist house over the stock bins. The original arrangement of the bins in the stock house, which provided for a separate charging of coke from the bin into the bucket by means of a conveyor, has been modified so that the operation of charging will be under the control of a single man.

The proximity of this plant to the ore mines has obviated the occasion for storage facilities for ore, and as a result has considerably simplified the arrangement of the stock house. in the summer season the plant will receive daily shipments, with enough ore on track for 24 hr., and for winter shipments, which are likely to be frozen in transit, a sweat-house is built with capacity for steaming a 36-hr. supply of ore. What is true of the plant in general is true of the stock house with respect to trestle approaches to the building. Wherever possible excavation has been made, lowering the building elevations and yielding in many instances material for the manufacture of the cement blocks with which the mill buildings are erected. In consequence, the elevation of the top of the rails over the ore, coke and stone bins in the stock house is but 8 ft. above the tracks at yard grade, while the rails at bottom of the stock house below the bins are approximately 26 ft. 6 in. below yard grade. A cross section of the stock house is shown in Fig. 1, indicating the double track arrangement for filling the bins above and below, and for shifting the charging buckets for coke and stone and the several kinds of ore. Baldwin-Westinghouse electric locomotives are used for handling the cars in the stock house.

The gas from the top of the stack is taken off at four risers and brought down in two down-comers to two 20-ft. dust catchers. From the dust catchers the gas passes through 10-ft. Brassert whirlers, and then into 18-ft. grid spray primary washers. The gas for the power plant goes through a further washing process in a battery of Ernst secondary washers.

---

*Abstracted from article in The Iron Age of Dec. 30, 1915.

The probable expectancy of high hot-blast-stove efficiency appears to have been offset by the extra provisions for extreme winter temperatures in the building of five stoves for each stack. There is a central stack construction for each group of five stoves. Each central stack has a diameter of 9 ft. 6 in., the individual stack connections from each stove being 5 ft. in inside diameter.

The Open-Hearth Plant.

The open-hearth group consists of a main building 984 ft. long by 141 ft. wide, the charging-side bay of the building being 77 ft. 7 in., and the pouring side 63 ft. 5 in. The building provides for ten 75-ton open hearths spaced 84 ft. on centers; seven of these furnaces are now completed. A cross section of the open-hearth department is shown in Fig. 2.

Auxiliary to the open-hearth building is the stock house. This building is 436 ft. long by 80 ft. wide, and it is arranged with a platform at the open-hearth charging floor level for the storage of charging trays on tracks and also for the entrance, at the ground level, of two raw material tracks. This building, which is spanned by a 10-ton crane, is shown at the right in Fig. 2.

The gas-producer plant consists of one battery of ten producers and one of eight, with provision for the installation of an additional ten, together with the coal bin and charging facilities and a battery of 437-hp. waste-heat boilers, one for each open-hearth furnace.

The mixer building is a wing on the main open-hearth building, arranged for receiving hot metal on a direct track from the blast furnaces; it houses the 600-ton mixer (see Fig. 2) and has provision for the subsequent duplication of this mixer. This building is served by a 75-ton crane.

The approach to the charging floor of the open-hearth building is a gradually ascending trestle from the hot metal tracks of the blast furnace plant. This approach does not lead directly into the open hearth building, but to an elevated runway from which the stock house opens directly on one side and over which are hung the ore, limestone and dolomite bins for the open-hearth supply.

Below this runway are the material tracks, at the ground level, which span the receiving hoppers for raw materials, from which these materials are delivered by elevators to the bins above.

Directly below the runway which separates the stock house from the gas producer installation are the tracks on which also the coal for the gas producers is received. From cars on these tracks the coal is dropped into 70-ton track hoppers, which deliver it to a double ship hoist. This hoist elevates the coal and discharges it onto a belt conveyor, which delivers it to an overhead bin having a capacity of 3.4 tons per linear foot, or approximately 56.6 tons per producer, the producers being spaced 16 ft. 8 in. on centers. The coal bin is constructed of steel plates with a 3-in. concrete lining. The producers are of the Hughes mechanically-poked type, and the battery is mounted above a standard-gage track, which affords facilities for the removal of the ashes. In addition to the novel arrangement for the handling of coal to the producers there is an additional feature in the carrying of the gas to the open-hearth generators through overhead gas mains. The gases from the furnaces are carried through the boilers by induced draft created by a 60-in. Sturtevant fan, one for each boiler, with a direct discharge into the stack. The stacks are of concrete, 6 ft. in diameter.

The hearth of the open-hearth furnaces is 40 ft. long and 16 ft. wide, with a height of 9 ft. 11 in. from bottom to back. The back, which is 12 in. thick, is arched on a 24-ft. radius, and the width of the combustion port is 4 ft. The supporting structure of the furnace is exceedingly heavy, as will be noted by referring to Fig. 2. The furnaces are equipped with Knox water-cooled ports and doors, the latter being electrically operated. The furnaces are charged by a Morgan low-type machine. The arrangement of the furnaces is conspicuous for the liberal allowance for passageways on all sides of the furnace, particularly around the columns on the pouring side. The charging side of the open-hearth building is spanned by 100-ton cranes, and the pouring side by 150-ton cranes.

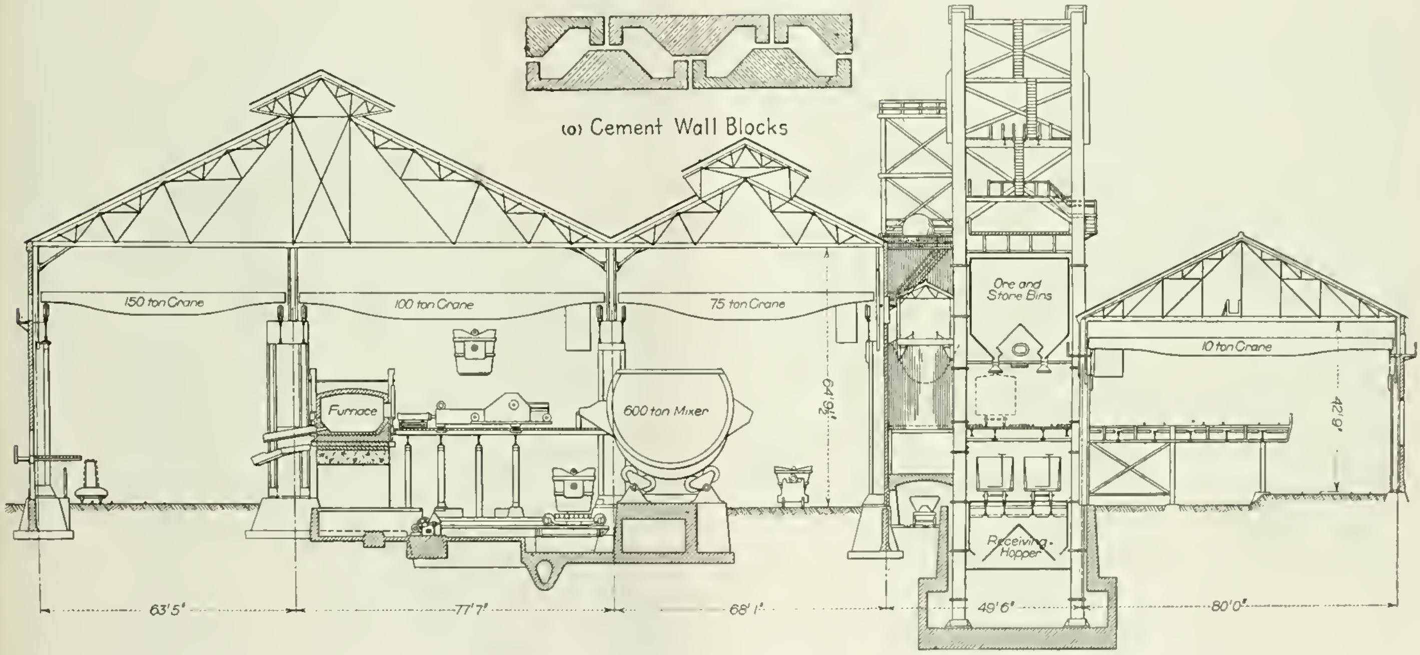


Fig. 2—Cross-Section of Open-Hearth Department of Duluth Plant of Minnesota Steel Co., Showing Type of Buildings and Equipment.

The Rolling Mills.

On the pouring side of the open-hearth plant three platforms are provided for pouring the ingots, and from each of these there is a run-out track through the side of the building to the ingot yard, which parallels it. From this yard the approach is direct to the soaking-pit building, which is an extension of the blooming-mill structure. The soaking-pit building is 390 ft. 6 in. long and 95 ft. wide. The ingots are stripped immediately after entering the building at the northwest end by means of a 150-ton Morgan stripper crane. There are provided four 4-hole soaking-pit furnaces with electrically operated covers. This affords an aggregate capacity for the simultaneous heating of 96 ingots, which are charged into the pits by means of two 7½-ton Morgan charging cranes. The battery of gas producers for these furnaces is located in an adjoining building, the gas being preheated by means of an economizer through which the waste heat from the furnaces exhausts.

The soaking-pit building being an extension in a straight line of the blooming-mill building, the approach to the blooming mill parallels the furnaces.

The general layout of the blooming mill, 28-in. rail mill and 18-in. mill, with hot beds, finishing departments and crane equipment, together with their relation to the merchant mill, are shown in Fig. 3.

The mill presents its most conspicuous departure from the ordinary mill layout, where no attempt is made to roll such a variety of products, in the provision for reheating the blooms and billets. The bloom or billet delivered from the blooming mill is sheared to 16-ft. lengths in a Morgan electrically operated gap shear, from which it passes to a rotary transfer. This transfer is arranged to permit the continuous passage of the steel in a straight line from the blooming mill to the first stand of the rail mill, but its purpose is to transfer the 16-ft. length to the cross table at 90°, on which table it is delivered to the 16-ft. continuous reheating furnaces.

The furnaces are heated with producer gas and are operated in the regenerative principle. Three reheating furnaces are installed. Each furnace is served by an hydraulically operated charging ram, which receives the steel billet from the transfer table, elevates it to the height of the furnace charging opening and pushes it into the furnace. The movement of the steel in course of reheating through the furnace parallels the run of the mill. At the delivery end of the furnace the billet discharges on a second transfer roller table, upon which it may be either returned to the 28-in. rail mill or pass in the opposite direction for delivery to the continuous stands of the merchant mill, a rotary transfer at either end of the transfer table rotating the billet for its delivery to the mills. It is the expectation that practically all of the steel will be reheated.

The arrangement of the mill following the delivery of the finished pieces from the last stand to the row of five hot saws is indicated in Fig. 3. After passing the marker and cambering machines the rail or other sections are delivered to the hot beds, which have a length of 175 ft. and a width of 113 ft. 4 in. At the delivery side of the hot beds the roller table extends in each direction. Toward the right the rails are delivered to the rail finishing department, and toward the left the tables deliver to the structural and bar finishing departments. Directly opposite the hot beds provision is made for the shearing and punching of the plates and the finishing of splice bars, as well as the storage of spikes and bolts. In each of these finishing departments access can be readily had for shipping by direct track from the yard.

The following sections are rolled at the Duluth mill:

On the 28-in. rail mill.

Rails	100-lb. to 60-lb.
Channels	9, 8, 7 and 6-in.
Beams	8, 7 and 6-in.
Angles	6x6, 6x4, 6x3½, 5x4, 5x3½, 4x4, 4x3½, 4x3 in.
Flats	10 to 6-in. by 1¼-in. thick to ½-in.
Rounds	5 to 3½-in.
Squares	4 to 2¾-in.

On the 18-in. rail mill.

Rails	45 to 20-lb.
Channels	5 and 4-in.
Beams	5, 4 and 3-in.
Angles	3½x3½, 3½x3 and 3x3-in.
Flats	6 to 4-in. by 1½-in. thick to ½-in.
Rounds	3⅜ to 2½-in.
Squares	2½ to 2-in.
Angle splice bars	100 to 60-lb.

On the Merchant Mill.
Full range of bar sizes and sections.

The cooling, shearing and straightening equipment of the merchant mill is of the standard type furnished by the Morgan Construction Co. The cooling bed is 300 ft. long, and it delivers material from either side, the bed sloping down from the hot run-out rolls in the middle to cold run-out tables at either side. These cold run-out tables deliver the bars to shears, and from the back shear tables the bars pass, on the one side, to a roller straightener, and on the other to an angle straightener. From the center line of these straighteners to the center line of the first pair of shuffling bars the distance is 8 ft. 2 in., and from the first pair to the last pair of shuffling bars the distance is 60 ft. Then follow additional shears for cutting the bars to short lengths and, at the end of the mill, scales and bins from which to finally deliver the material for shipment.

Building Construction.

The type of buildings used in the open-hearth plant are indicated in Fig. 2. The walls of all the mill buildings consist of cement blocks of the form shown in Fig.

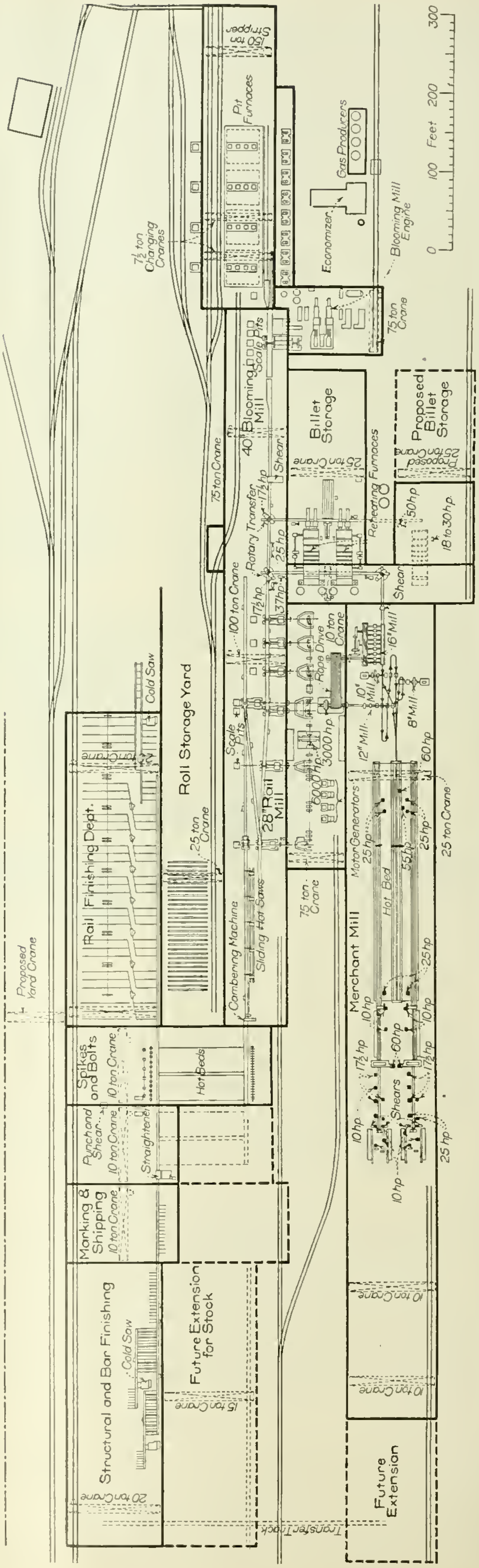


Fig. 3—Plan of Rolling Mill and Finishing Department of Duluth Plant of Minnesota Steel Co.

2 (a). The result is an exceedingly substantial and warm building. The construction is also relatively cheap, largely because of the manufacture of the blocks at the works from material excavated in the construction of the mill. The use of rough finished cement walks in most of the buildings, and of channel sections laid with the flanges projecting upward and filled with concrete for steps in all the areaways, are also features. Profiting from the experience with excessive vibration in buildings which house gas engine power plants, the foundations for the engine units at this plant are completely isolated from the building itself. In the floor construction a continuous ¾-in. gap separates the concrete piers from the concrete floor of the building.

Personnel.—The organization which will conduct the operation of the Duluth mill includes George L. Reis, vice-president; S. B. Sheldon, general superintendent; K. C. Hoxie, chief engineer; W. R. Pendry, superintendent of coke ovens; A. O. Baer, superintendent of blast furnaces; P. B. Wheeler, superintendent of the open-hearth department, C. A. Thayer, superintendent of the rail mill; C. C. Sampson, superintendent of the power station, and J. H. Smith, master mechanic.

FURTHER COMMENT ON A NEW ASSOCIATION OF ENGINEERS.

To the Editors: Your editorial under date of January 12 should draw enough fire from the engineering aggregation to determine their future status, and in this connection let me say that the average engineer holds the key to the situation. His beginning is in obscurity, and even though he may survive solitary confinement, small wages, "logs," functions, Searles, and the rigid Darwinism of field work, individuality can seldom lift him above the average of his class. When we consider the mental attitude engendered in the host of satellites who chain, compute, delineate and deliver the gravitational power that holds great engineers in their orbit, who gather and check the essence of much advertsiing data, why chide their lack-lustre interest. Accuracy, experience, and fidelity call him across the states to lay down a railroad "center line," bore a water-soaked subway, or blueprint a hypothetical bond issue, for a figure less than a third-rate bank clerk's salary.

Aiding, then, the mental stimulus of this average engineer, to whom is entrusted the major part of physical engineering, is a problem worthy of united effort. It must be apparent that any organization composed mainly of professional and academic men is helpless in reaching the average self-made worker. The line of demarcation between consulting or contracting engineers and their employes is too sharply defined to permit their being gathered into the same organization, without segregation into classes. Their relationship then so nearly approaches that of employer and employe that meeting on the common footing afforded by present organizations does not adequately provide for the employe.

Remedial measures must provide for the field men, whose long months on the "firing line," with its usual grind and the concentration necessary to fast, accurate work lose these men to the outside world and the various phases of engineering. They have little time to promote their own welfare if they live up to the traditions which demand pushing the job until through, and they usually spend their savings either in looking for work or in forgetting the unpleasant features of the last job. In either case, they must accept the first thing offered at whatever price it may be.

Any improvement in the morale of engineering must come from within, and it is not a travesty on the profession to provide every possible means against unscrupulous incursions upon the public good will. The employing public will soon realize the value of the district office in supplying engineers qualified in the particular line of work to be done, and the price for such work will, to a certain extent, become standardized.

In the following memorandum are the essentials of an organization culled from the ideas of men who have gone from chainman to chief, and it is sincerely believed the majority of workers in the profession will readily subscribe to them:

1. **Location and Membership.**—Any of the present organizations that will reorganize along more liberal lines, providing for field members, or a new organization with headquarters in Chicago or an equally central city and with suitable branches on each coast, will serve the purpose. This organization should be made available to all engineers: civil, mining, hydraulic, irrigation, bridge, structural, electrical, and mechanical branches. The headquarters and branches should collect data, file "Members' Report Cards," carry on publicity work, and arbitrate matters for members.

2. **Classification.**—Six classes should be provided, as follows, each class embracing a distinctive step in accomplishing the work of the profession:

First class, consulting and contracting engineers.
Second class, chief engineers.
Third class, division engineers and chiefs of party.
Fourth class, officemen, draftsmen and computers.
Fifth class, instrumentmen.
Sixth class, rodmen, chainmen, flagmen, stakemen, etc.

3. **Affiliation.**—Affiliation should be made by applicant, filing application card with the district office, giving name, age, employer, experience, places employed, education, and last position. If experience and record warrant class applied for, the applicant is filed under same. Any information regarding nature of work is filed with the member's name and class.

4. **Change of Employment and Location.**—Notice shall be sent to the district having jurisdiction, giving name, class, position and employer, which shall be filed and dated so that the member's tenure of position will be of record, with date from actual filing; the purpose of this being to hurry the report cards into the district offices. Any new additions to a force shall file report cards as soon as on the job. These report cards are to be countersigned by the chief engineer or, in his absence, by the member in responsible charge; they are designed to aid in providing a continuous record of experience for each member. A report card showing work finished shall be filed with the nearest district office upon the completion of any job, giving name and class of all members who are employed at that time. This card shall be forwarded to the district office by the last member in charge. Discharge of any member shall be filed with the district office by the engineer in charge, or if the engineer in charge is not a member of the association by the member so discharged. Provision should be made for examining into unwarranted dismissals of members who are in responsible charge of work, when such members demand it, by the Arbitration Committee of the district.

5. **Promotion.**—Advancement to a higher class is based upon fitness as determined by the member in responsible charge of work and must be filed with the district office to give the member advantage of the advanced classification. Report card should give name, class, present and advanced position, and reasons for advancement.

6. **Work Reports.**—Any member upon accepting responsible charge of work must file notification with the district office, giving firm, location, character of work, together with his name, class and position. Blank report cards must then be forwarded at once to him for use in reporting the personnel of the organization.

7. **Report Cards.**—Report cards should be so made as to be used for application, advancement, work reports, and discharge, also for reporting prospective work, so as to keep the district offices advised for publicity purposes; these cards should be of convenient, mailable size.

8. **Publicity.**—Newspaper articles, treating of subjects in a popular rather than technical manner, should be furnished for publication looking toward attracting public attention to the association and to the work of its mem-

bers; in addition, proposals, contracts let, and new work projected should be scanned for the information of members and the public.

Very truly yours,
J. B. Thompson,
Civil Engineer, Stanford University's Ranch.

Vina, Cal.,
Jan. 24, 1916.

A SAFETY DEVICE FOR SWINGING SCAFFOLDS.

A simple and effective safety device for swinging scaffolds is illustrated in Figs. 1, 2 and 3. This device is easy to operate, and it can be rigged up by any workman who desires to protect himself by its use. As shown in the illustrations the device consists essentially of an auxiliary rope, or stout cord, at each end of the platform, so arranged as to hold the hoisting ropes securely and prevent them from moving except at the proper time and in the proper manner.

The idea can be carried out in a number of ways, differing in detail. In the arrangement shown the middle part, which is of window cord about 3/8-in. in diameter, is wrapped three times around the free end of the supporting fall, and the two parts of the cord are fastened together near the fall with metal clasps, or by binding them with a stout cord or wire. The two ends of the cord are then made fast to the scaffold-iron or hanger in such a way that the part which encircles the supporting rope will stand at a height of about 4 ft. above the level of the platform when the cord is extended.

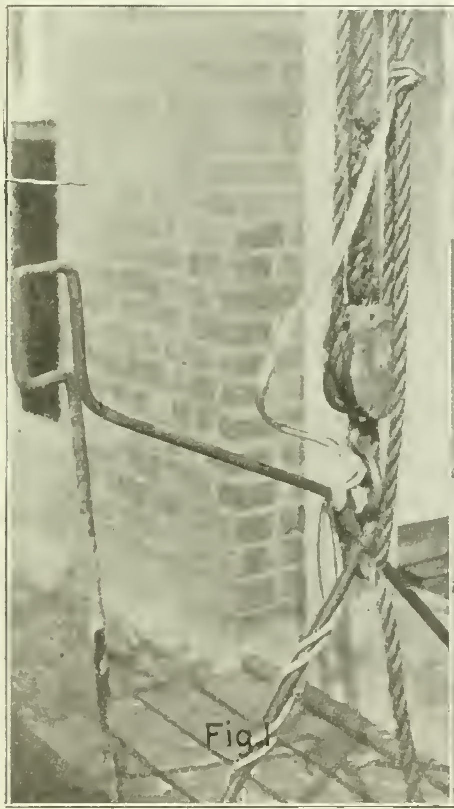


Fig. 1—View Showing Fall Secured to Hook with Safety Rope Slack.

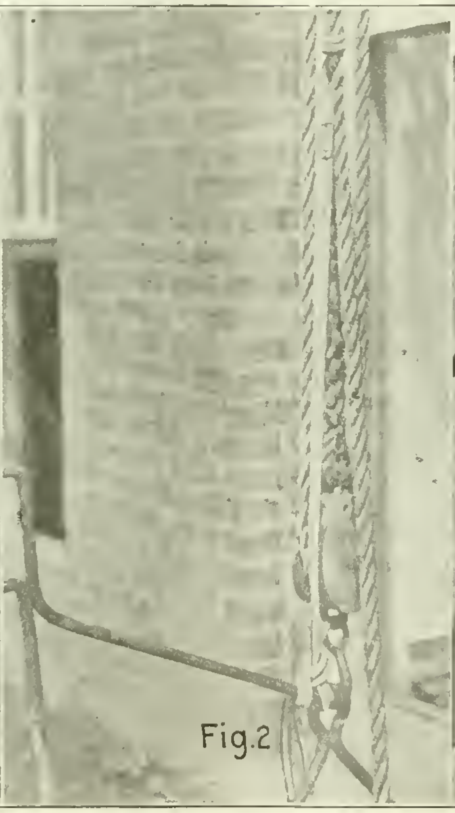


Fig. 2—Fall Disengaged from Hook with Safety Rope Taut.

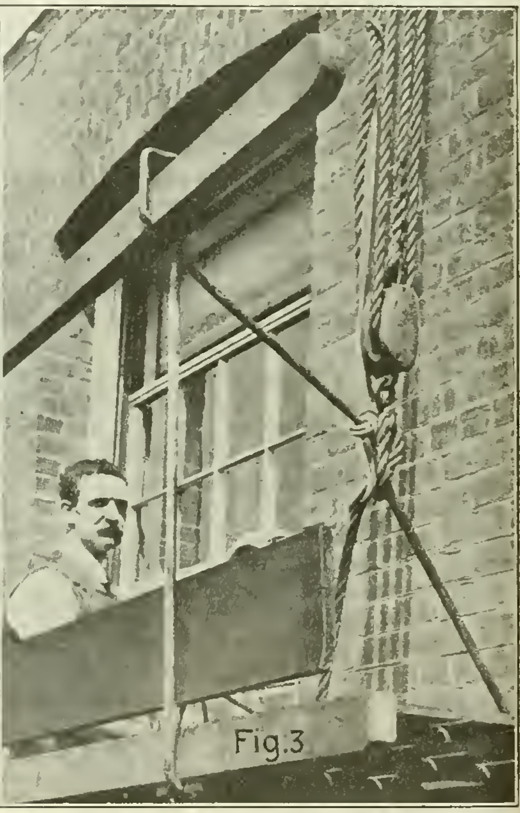


Fig. 3—End of Scafford Fitted with Safety Device.

In raising or lowering the scaffold each workman grasps the free end of the fall at his end of the platform in such a way that one hand surrounds the part of the cord which encircles the fall. As he shifts his hand upward or downward on the rope he slides the loop of cord along it at the same time. If either man should lose hold of his supporting rope the end of the scaffold will descend a few inches, but the cord, as soon as it is drawn taut, will bind tightly against the supporting rope and prevent further movement. In using the device the men should never rely on the auxiliary rope for sustaining the scaffold under normal conditions, but should always hitch the free end of the supporting rope in the usual way, over its hook. The device was worked out experimentally by the Royal Typewriter Co., of Hartford, Conn., and described in The Travelers Standard.

EARTH ROAD MAINTENANCE BY DRAGGING IN MINNESOTA.*

By John H. Mullan, Deputy State Engineer, Minnesota.

The county engineer or superintendent is in general charge of work under this system and enters into contract for the county with residents along the road, to drag certain definite sections after each rain and whenever ordered by him. These sections may vary from one to three miles for team haul and up to ten miles or more with a tractor. In contracting this work a price per mile for dragging and per hour for extra work, such as clearing ditches, etc., is agreed upon and it is stipulated that the price of the first few draggings be retained until the end of the season and any neglect to drag when necessary be compensated for by deduction from the retained percentage of an amount which would otherwise have been paid to the contractor for the work which should have been done. It is manifestly impossible to closely check this work, but by having a system of reporting by post card immediately after each dragging and using these reports as a basis for making monthly payments, it is found that few errors occur, and the engineer is generally given considerable voluntary assistance and information by those using the road. The telephone is a valuable adjunct to this work and it is found that after the work is well under way the engineer can select the best man in each locality and entrust him with the authority to call out the drags by phone when necessary and he can also save considerable telephone charges by having such men spotted to distribute hurry-up-orders to the draggers.

The kind of a drag to use has been quite a study, and although many of the so-called log type are in use it has been demonstrated that the light graders and road planers are much better for the reason that the ordinary drag does not level the road longitudinally, but on the contrary tends to gouge out depressions, while an implement similar to the Minnesota Road Planer will level the road longitudinally as well as transversely and will reduce the waviness found so objectionable on many highways.

There is a question as to whether dragging shall be done by tractor or teams. At Owatonna, Minnesota, a comparison was made between drags drawn by a team which cost on the average 52 ct. per mile for the season with team and man at $4 per day. A light tractor with two-way drag, costs an average of 29 ct. per mile for the same service, taking into account all charges including depreciation of 20 per cent on outfit for the year. The engine was used to haul gravel when not dragging which brought the cost of plant down considerably in figuring the dragging. This comparison would indicate that a maintenance section equipped with a light tractor might be the best organization.

---

*Extract from a paper read at the Wisconsin road school at Madison, Wis.

The amount of dragging or maintenance work depends upon the season and soil condition, and in our experience runs from about six to 35 draggings per year, while some of the sand roads are dragged very seldom—only enough to bring back to the wagon tracks the straw which is placed as a part of the maintenance work.

A NEW FUEL OIL DRIVEN AIR COMPRESSOR.

(Contributed.)

Compressors of the type illustrated by Fig. 1 are guaranteed to run on any mineral oil of 28° Beaume scale or lighter, containing not over 1 per cent sulphur. There are a number of oil wells below 28° Beaume scale on which they will operate satisfactorily, but this depends upon the characteristics of the particular oil, such as its asphaltum content, freedom from sand, etc., so that a general guarantee cannot be given, though recommendations for heavy oils can and will be made. Most of the common crude oils, fuel oils, and residuums are naturally included in the above guarantee. A few of the well-known oils particularly suited to the operation of the compressors are as follows: Star oil, Diesol, Calol, Stove oil, Solar oil, Gas oil, kerosene, and all of the distillates between kerosene and lubricating oil.

A number of the above fuels are obtainable for 3 ct. per gallon, so that the compressors are warranted to compress air to 100 lb. pressure at a cost not exceeding 56 ct. per day of nine hours for each 100 cu. ft. per minute of free air delivered to the receiver. These figures are so astonishingly low as to seem almost incredible. The facts, however, show that there are dozens of these machines in service with daily records of fuel consumption that bring their costs of operation well under the amount stated.

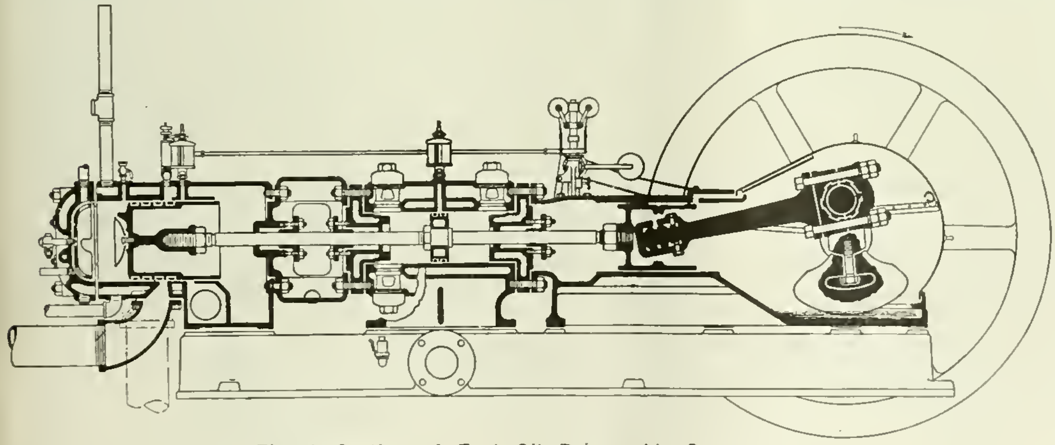


Fig. 1—Section of Fuel Oil Driven Air Compressor.

As shown by the illustration these compressors are of the horizontal, straight line, single stage type with compressing cylinder bolted to the main frames and closely connected in tandem to the power ends. The propulsive cylinders are of the valveless, two-cycle, low compression design. Ignition is produced by a patented, positive acting hot-plate system, that eliminates all electric apparatus, such as magnetos, timers, mixers, and spark plugs. Just as in the Diesel engine, combustion takes place at the end of the compression stroke. The importance of this exclusive feature of design is immediately apparent. Air only is compressed in the cylinder, and combustion is so complete by the time the exhaust port is opened that the fuel loss is negligible. The result is attained through the medium of a small oil pump which injects the fuel against the hot plate on the piston as it approaches the end of the compression stroke. Increased economy is obtained by the use of water with the fuel oil. The quality of both oil and water admitted to the combustion chamber is controlled by a fly-ball governor.

The new compressors are made in both single and duplex machines. Single compressors come in six standard strokes, 8, 10, 12, 14, 18 and 21 in. The smaller sizes may be tank mounted and the larger types set on skids so that their use is not confined to stationary requirements. The manufacturers are the Chicago Pneumatic Tool Co., Chicago, Ill.

THE WORK OF THE IOWA STATE HIGHWAY COMMISSION IN 1915.

There are more than a 100,000 miles of public highway in Iowa under the general supervision of the Highway Commission, more than 17,000 miles of county highways, and a total of probably close to half a million bridge and culvert waterways under the direct supervision, in a way, of the Commission. It is estimated that the total road and bridge expenditures will reach above $11,000,000. The total Commission expenditures for the year covered were $80,935.16, or less than 1 per cent of the total expenditure.

During the season the bridge department designed 459 bridges for 76 counties, estimated at $1,182,000, checked in detail 436 designs submitted for approval from 78 counties, made 40 inspection trips, developed new standards for both steel and concrete structures totalling 48 designs, passed upon and reported for approval 172 bridge contracts amounting to $1,337,069, passed upon and reported for rejection bridge contracts amounting to $37,300, as reported on 49 material contracts submitted from 22 counties, and investigated 92 complaints on bridge and culvert work from 62 counties.

On railroad crossing improvement work the Commission listed complaints on 112 projects, prepared detailed plans on 46 projects estimated at $211,400, approved plans on 8 projects, held 37 conferences and adjusted a total of 41 projects, which improve 33 crossings and eliminate 21 crossings.

The road department passed upon plans for the permanent grading of 549 miles of road, undertook the settlement of 254 road complaints, passed upon road contracts totalling $71,000, made detailed daily inspection upon the construction of 2 miles of concrete road, prepared plans for and gave detailed supervision to the permanent grading of 6½ miles of state road work at state institutions, which required 369 days' work and spent 148 days in the field on other classes of work.

The field engineers have attended 84 material lettings, 27 road lettings amounting to $230,562, 140 bridge lettings amounting to $1,679,165, made field investigations of 110 complaints, took up personally with each county engineer the preparation of his annual report, inspected bridge sites, approved grade lines, and gave such general supervision to the highway work that 1,641 days have been spent in the field.

Members of the Commission and the force have held 45 road meetings in 34 counties and the Commissioners have spent a total of 131 days in 86 counties on inspections and in consultations with the highway officers.

DESIGN OF A CURVED CHORD REINFORCED CONCRETE HIGHWAY BRIDGE AT LYONS FALLS, N. Y.

(Staff Article.)

The highway bridge over the Black River canal, at Lyons Falls, N. Y., is a reinforced concrete structure of somewhat unusual design. It has a clear span of 56 ft. 8 in. and provides a clear roadway of 17 ft. The floor system is suspended from two arch ribs, at intervals of 7 ft. 1 in., these ribs projecting 11 ft. 8 in. above the curb at the center of the span. The arch ribs are spaced 21 ft. 9 in. on centers, the thrusts being resisted by ties placed in the plane of the floor system. The bridge is designed to carry a live load equivalent to a 15-ton truck. The general design features of the structure are shown in Fig. 1. It will be noted by referring to this drawing that the bridge is on a skew, the face of the abutments forming an angle of 72° 24′ with the longitudinal axis of the bridge.

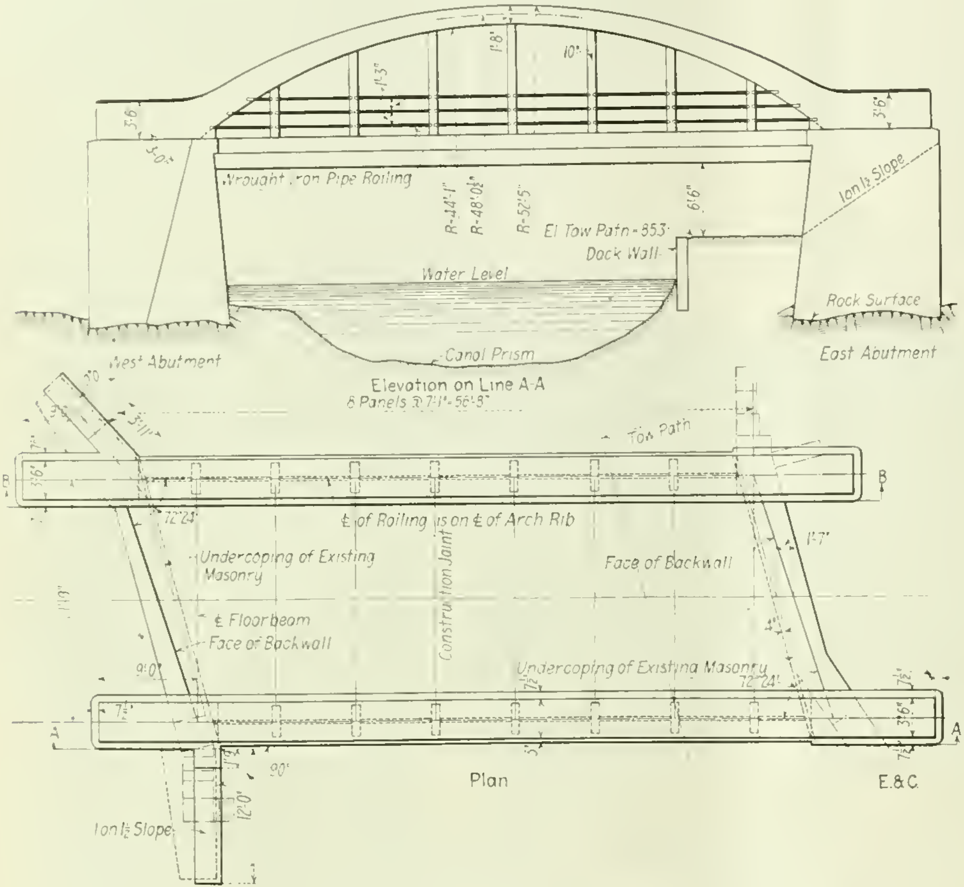


Fig. 1—General Plan and Elevation of Highway Bridge Over Black River Canal, Lyons Falls, New York.

Arch Ribs.—Each arch rib has a thickness at the crown of 1 ft. 8 in. and a uniform width throughout of 3 ft. 6 in. The intrados is on a curve of 44 ft. 1 in. radius, while the extrados forms a curve of 52 ft. 5 in. radius. The ribs have a rise of 10 ft. The reinforcement of each arch rib consists of four 3x3x5/16-in. angles single laced, the top, bottom and side lacing consisting of 2½x5/16-in. bars. The top and bottom angles are spaced 12 in. apart at the crown, this spacing increasing toward the springing line, to conform to the shape of the arch ribs. Complete details of these ribs are shown in Fig. 2.

Hangers.—Each floorbeam hanger has a width 2 ft. 10 in. and a thickness of 10 in. Its reinforcement consists of four 3x3x⅜-in. angles, spaced 2 ft. 4¼ in. back to back and single laced with 2¼x5/16-in. bars. The reinforcement is designed to take all of the stress in the hanger and it is securely riveted both to the arch reinforcement and to the floorbeam.

Floor System.—The floor system consists of built-up steel floorbeams, encased in concrete, supporting a reinforced concrete floor slab.

The floorbeams have a span of 21 ft. 9 in. and are spaced 7 ft. 1 in. on centers. Each beam consists of four 5x3½x7/16-in. angles, spaced 1 ft. 8¾ in. back to back, and one 20x⅜-in. web plate. Details of these floorbeams and of their connection to the hangers are shown in Fig. 2.

The floor slab has a thickness of 9 in. at the crown and 8 in. at the curb. It has double reinforcement, the longitudinal rods being continuous over the floorbeams. De-

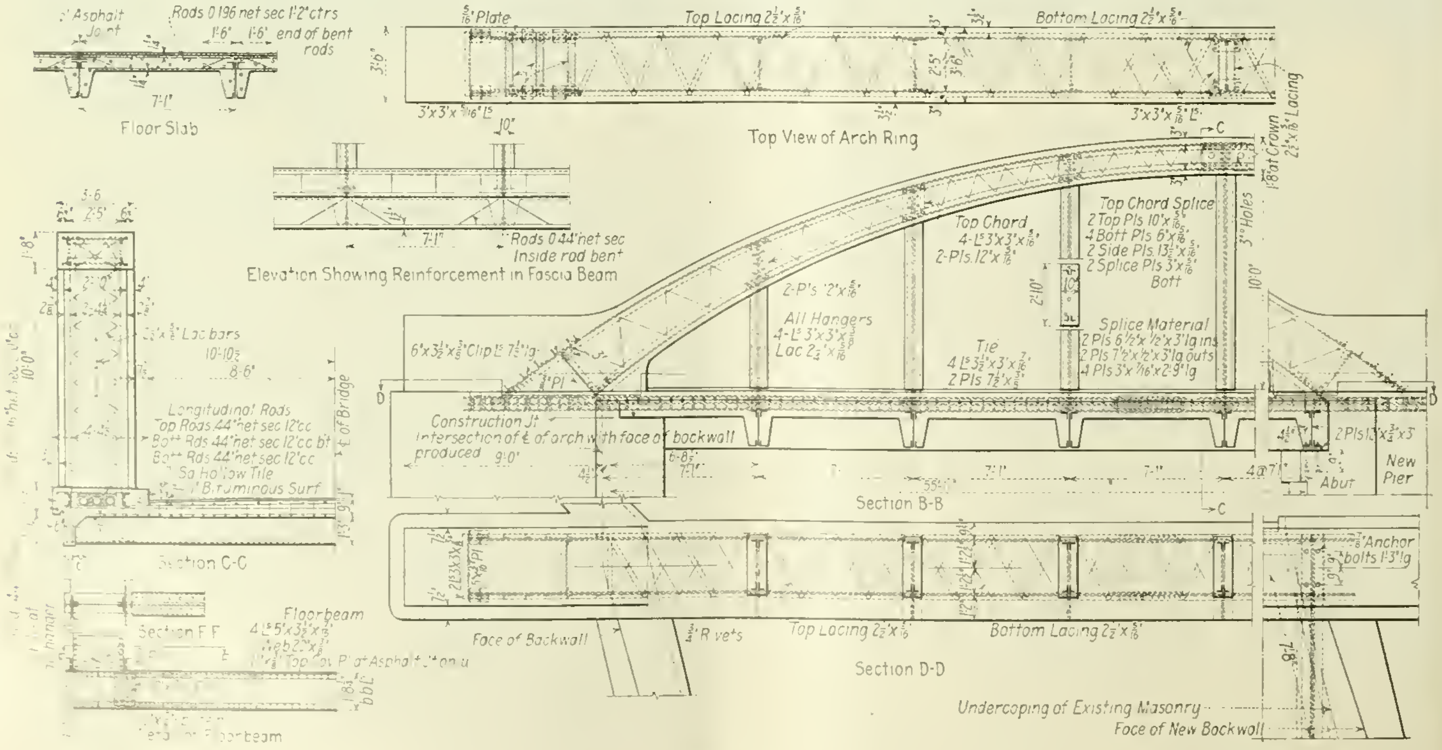


Fig. 2—Details of Superstructure of Highway Bridge Over Black River Canal, Lyons Falls, New York.

tails of the floor slab, showing the arrangement of the reinforcing bars, are shown in Fig. 2.

Arch Ties and Fascia Girders.—The tie which resists the thrust of each arch rib is placed in the space between the curb and the fascia girder. It consists of four 3½x3x 7/16-in. angles and two 7½x⅜-in. plates, with 2½x5/16-in. single lacing at the top and bottom. The angles and plates are placed just outside of the reinforcing units of the hangers, thus forming a space for conduits. Details of these ties and of the anchorages are shown in Fig. 2.

The fascia girders are of the form shown in Section C-C, Fig. 2. They extend 1½ in. below the bottom of the floorbeams and form an anchorage for the ends of these beams.

Abutments.—The abutments are of the form shown in Fig. 1, these abutments resting on solid rock. They occupy approximately the same position as the masonry abutments of the old bridge which is replaced by this structure. The old masonry below a plane lying about 2½ ft. below the floor surface is left in place and is bonded to the new concrete. As will be noted by referring to Fig. 1, wing-walls are provided at the west end of the bridge to retain the fill. The relative positions of the new and old masonry are shown in the general plan.

The bridge was designed and its construction supervised by the Highway Department of the State of New York.

METHODS OF REMEDYING SLIPPERINESS ON SURFACE TREATED MACADAM ROADS.*

By Burr Powell Harrison, First Assistant Engineer Maryland State Road Commission.

Generally a macadam road in Maryland receives an application of some bituminous material, ½ gal. per square yard for its first treatment, and this bituminous material is then covered with stone chips. As a rule the first treatment does not make the road slippery, the bituminous material going down into the road filling up the voids, but making no mat, leaving the stone projecting slightly, thus preventing slipperiness. This is more noticeable when the road is built of trap rock than when built of limestone. It is after receiving the second application that all voids become filled and the road has a thin mat upon it. This hard, smooth mat becomes slippery when it is wet or icy.

Sanding to Prevent Slipperiness.—Up to the fall of 1914, the method pursued in Maryland was to spread sand over the roads. Fortunately there is in Maryland a quantity of local material sufficiently good for this purpose, especially on the Eastern Shore, and also in certain localities on the Western Shore. The method of sanding the roads when they became too slippery answered every purpose up to the winter of 1914, as there were few complaints received up to that time. This was due principally to the fact that giving the roads a surface treatment was only begun in Maryland in 1910, when 38 miles were treated. At this time, we had only a small mileage of roads built, so the cost was small. In 1914 approximately 450 miles of road were given a surface treatment. By this time a number of contracts had received several treatments and the number of complaints of slipperiness increased accordingly.

In 1913 we received more complaints of slippery roads from Harford County than from any other county in the State. This county is hilly and rolling and consequently has a large number of grades, some of which are bad. In 1913 a tar material was applied on the roads of this county. In 1914 a soft asphalt material was applied on the same roads with the idea in view of remedying the slippery conditions that existed in this county in the winter of 1913. This asphalt was applied on top of the tar and was especially selected as being the softest asphalt surface material known to us at that time. The results obtained were not altogether satisfactory. This may be partly due to the fact that the asphalt material was applied on top of a tar. The search for a binder which will not only hold the macadam roads, but at the same time not be slippery, was continued in 1915.

Sanding a road is very expensive, especially if sand cannot be found in a nearby local deposit or stream, and has to be imported, in which case the freight must be added to the cost. After sand has been spread on a road at big expense, a few high winds may come along and blow it all away. Even if you are lucky enough to escape winds and rains, you cannot escape the automobiles which travel the hard roads the entire year. In a very short time these automobiles will make the roads look as though they had been swept with a broom.

Assuming the cost of sand as 35 ct. per ton or 42 ct. per cubic yard, it will cost approximately $25 per mile to sand a 14-ft. road, ¼ in. deep, without taking into consideration the freight or the labor in spreading or hauling.

In Maryland beginning with 1914, there was so much slipperiness that the expense of sanding all slippery stretches was prohibitive, especially in view of the fact that it might be necessary to resand the same stretch more than once, and it became absolutely essential to find some other method more economical.

Separate Roadways for Horse and for Motor Vehicles.—The proposition has been advanced to build two roads, one for the automobile, and the other for the horse drawn traffic. Another proposition has been advanced to build three roads, one for the horse drawn traffic with an automobile road on each side. While this procedure would do away with the objections now advanced by those interested in horse-drawn traffic, in reference to slipperiness, etc., the high cost of such construction makes it impracticable, except to very wealthy communities near large cities where it may be advisable. It may be well at times to extend the shoulders of roads on grades which would relieve the dangerous conditions to a large extent. This method would be advantageous on roads where traffic is increasing so rapidly that the road would have to be widened in the near future.

A Material Not Slippery.—At this writing, we are not in a position to state whether or not we have found a surface material that will bind the road together, and, at the same time not be slippery, still we applied an asphalt material in the summer of 1915 which gives us some hope in this direction. The results obtained have been most satisfactory except where it was applied on top of a tar material. We now have this material under close observation, but it has not been applied sufficiently long for us to say more than it now gives us much encouragement in regard to remedying slippery conditions.

Success of a Treatment of Tar, Sand and Gravel.—In the fall of 1914 numerous complaints were made about the slippery condition of our state road from Aberdeen to Belair, approximately 10.5 miles in length. About one half of this distance was constructed this year. The contractor had scarcely left the contract before the road was given a surface treatment with a tar material. Approximately six weeks later, a second treatment of a tar material was applied. This filled up all voids and made a thin mat over the surface of the road. The road, receiving two tar surface treatments immediately upon being constructed, when its surface and cross-section were so perfect, was made exceptionally slippery in cold or wet weather. It was the slipperiest road that has ever come under our notice. Knowing its dangerous condition, I asked permission of the chief engineer to try out an experiment to remedy the slippery condition and at once made requisitions to the purchasing department for the necessary material. There was a delay of a week or ten days in the arrival of the material.

When the materials arrived, unloading the cars at Aberdeen was begun. Twelve two-horse teams were used for this purpose. The inspector who looked after the unloading reported that every horse he had fell at some time and on one occasion he had twelve horses down at the same time. This happened while going up grade. On one occasion, while making an investigation into the slipperiness of the road before any remedy was tried, I questioned the patrolman and asked him how many horses had fallen on his section of four miles. He replied that he did not know. When asked if he thought as many as twenty-five had fallen, his reply was that he was quite certain that the number of horses that had fallen would be over a hundred. I go into details in reference to this road to impress upon you the exceptionally slippery condition it was in before the remedy for slipperiness was tried, also, to show how the farmer, living along the road and using it for driving and hauling purposes, felt in regard to it.

---

*Extract from a lecture delivered at Maryland Agricultural College, Jan. 14, 1916.

We had several cars of sand and washed pea gravel unloaded and hauled to convenient mixing points. We used Ugite "B" as the tar product. We mixed 66⅔ per cent sand to 33⅓ per cent of ¼ in. washed gravel together as you would mix sand and cement for concrete. We then added Ugite "B," thoroughly mixing it until we obtained a mixture of the consistency of putty. It was then shoveled into a one-horse cart and a second batch mixed. This was continued until the cart was loaded. To spread the mixture on the road, the patrolman should walk behind his cart and shake it off his shovel. He should not throw or cast it, as this would cause the gravel to separate from the tar. Experiment showed that neither stone chips nor washed gravel mixed with tar will give as satisfactory results as the mixture used. Experiment also showed that one-half sand mixed with one-half gravel or stone chips would not give as satisfactory results as the mixture used. We used pea gravel to give the mixture sufficient wearing qualities. We took great care not to get the mixture on the road too heavy, my idea being to roughen the surface so that it would stay in this condition only through the winter months, after which time it would wear off leaving the surface in a smooth condition.

An estimate made at the time the work was done showed it to have cost approximately $25 per mile, only roughening the slippery stretches and not the road for its entire length. The results obtained far exceeded my fondest expectation. The work and the results obtained had my personal supervision for several months. Frequent inquiry of the patrolmen, after the road was roughened, disclosed the fact that not a horse fell on the roughened sections after the work was done. Not one complaint of slipperiness was received in our office after the road had been treated. It was slightly objectionable to automobiles for a short time. Slippery conditions were not only remedied for the winter of 1914, but not one complaint has come to our office this winter regarding the stretches we treated. Our treatment has lasted satisfactorily for two years. This year we are roughening certain roads by this same method. Our cost runs as high as $47 per mile when roughening the entire length, which is seldom necessary.

DATA AND DISCUSSION ON EFFICIENCY IN PUBLIC UTILITY POWER PLANTS.*

By Charles Brossmann, Consulting Engineer, Indianapolis, Ind.

In the last few decades there has been a wonderful growth in utility plants of every description including light, water, heat, gas and other types of public service plants, whether private, municipal or a combination of both, and by utility plant I mean any plant that supplies service, and that is supported either directly or indirectly by the taxpayer. The earlier plants were naturally without the refinements found in the modern plant; in most cases a pump was a pump, boiler a boiler, and an engine an engine. No great importance seemed to be attached to the question of economy in the majority of cases, especially in the medium sized and smaller plants, and to tell the truth in this more enlightened day one finds that in some cases the above still holds.

However, there are a number of factors that have made the question of economy more important. Competition, the price of material, the desire for lower rates, public service commission laws and state regulation have all had a bearing in accelerating the question of economy.

It will probably not be disputed when the statement is made, that economy in its real sense is not generally practiced in this country as it should be; that expenditures of public money are in many cases not so judiciously handled as to show the greatest return for the investment.

This may apply as well to privately operated utility plants, as to public but the private plant is a quasi-public institution and is not so open to criticism or investigation as the municipal plant, except by legislative bodies.

One may ask what bearing has all this, the purchase and operation of equipment, on the public, on rates, on the relation to public service commission and regulation. Well, if it affects the rates and the service it has an important bearing.

Machinery was at one time largely purchased on bid price, often without regard for any other attribute and one still finds cases where it is purchased in extraordinary ways. I have known of utility equipment purchased in a way which reminds me of an old woman who went into a store, and said, "I want a pair of pants for my sick husband." "Yes, madam," said the salesman, "what size?" "Well," she said, "he wears a 16½ collar." Now it is not unusual for a 200-HP. boiler to be purchased because the plant has a 200-HP. engine, whether the water rate be 15 or 60 lb.

In the purchase of new equipment, requirements should first be carefully determined, all available records made as to loads and duties of old equipment. Then when requirements and limitations are fully known and properly charted bids can be intelligently received.

In receiving bids, in order to purchase economically, this can only be done by fully tabulating and charting the duties and guarantees and other important data, thus making a direct comparison. Thus, Fig. 1 shows the charting of 250 K. W. turbine generating units. The bids were tabulated after each bidder was asked to give guarantees and to fill a data sheet with the required information. After all data were received, tabulated and charted a proper comparison could be made. Note in the chart, Fig. 1, the average load condition for the day would be at about ⅝ capacity of machine, this shows a difference of 7 lb. of steam per K.W.; and at a 24-hour load and evaporation at boiler of 6 to 1 and coal at $2.50, the difference in fuel above is $1,825 the first year on this small unit.

This shows that to purchase economically it is not altogether a question of price or of salesmanship. The prospective purchaser should ask for bids and full data and then properly analyze them, giving due consideration to reputation of bidder and as to whether he is making bona fide or flash test guarantees or guarantees that cannot be met at all.

A guarantee and test to be of value must be properly secured and handled. This calls to mind the old days of water works contracting when competition was hot and all was fair. One veteran water works contractor in the days of coal duty guarantees, filled the entire back of his boiler bridge wall with coke, a gas house being conveniently near. It is needless to say the test run was a record breaker and very fully met the guarantees, in fact the safety valve kept popping off for a day after the test. Happily (for the owner at least) the days of such competition is over, however, it is still possible to get impossible guarantees in some cases.

Economy does not mean getting the lowest possible prices, but rather the highest result with least expenditure. Now right here I wish to quote Ruskin, who says, "All works of taste must bear a price in proportion to the skill, taste, time, expense, and risk attending their manufacture. Those things called dear are when justly estimated the cheapest. They are attended with much less profit than those which everybody calls cheap."

Now neither is the cheapest engine, boiler, pump, or other apparatus always the cheapest, nor is coal at the lowest ton price always the cheapest to operate. They must all be analyzed for the special conditions they are

---

*Paper before joint annual convention of Indiana Engineering Society and Indiana Sanitary and Water Supply Association.

TABLE I.—EXAMPLE OF ANALYSIS OF COAL FOR A LIGHT AND POWER CO.

		Fixed characteristics per pound.												
Proposition.	Price per ton.	B. T. U.	Fixed carbon, per cent.	Volatile matter, per cent.	Ash, per cent.	Sulphur, per cent	Moisture, per cent.	Loss due to moisture in B. T. U.	Actual B. T. U. per lb. allowing for moisture.	Addition in price per ton due to ash loss.	Actual cost of coal due to ash loss.	Actual B. T. U. per ton.	Number B. T. U. for 1 cent.	Number B. T. U. for $1.00.
1	$1.80	12,000	44.64	37.70	8.61	1.35	9.05	1,086	10,914	$0.043	$1.843	21,828,000	118,284	11,828,400
2	1.75	11,800	45.75	34.40	10.20	3.16	9.65	1,138	10,662	0.051	1.801	21,324,000	118,000	11,800,000
3	2.30	14,700	57.00	35.15	6.00	.60	1.25	184	14,516	0.03	2.33	23,032,000	124,600	12,460,000
4	1.80	13,596	52.26	36.40	6.69	.64	4.01	545	13,051	0.0334	1.8334	26,102,000	142,478	14,247,800
5	1.75	13,110	44.63	37.20	7.89	2.80	10.28	1,348	11,762	0.0394	1.8394	23,524,000	127,889	12,788,900
6	2.45	13,600	59.00	33.00	8.00	.75	.1	136	13,464	0.04	2.49	26,928,000	108,144	10,814,400

to operate under and unless properly determined there is liable to be a loss.

Take the purchase of fuel: Table I gives some coal bids; glance at the prices and heat characteristics. The coal with the highest number of heat units is not the best; the coal that is lowest in price is not the cheapest. Of the two lowest priced coals listed, although one is good as to heat units, both have the highest sulphur and moisture and ash content. These two coals are both $1.75 per ton. There are two coals, both at $1.80 per ton, but one of these gives 14,000,000 heat units for $1, while the other gives only 11.600,000 for $1, so you cannot tell by price alone or by B. T. U. per pound alone; all factors must be considered.

Now one of the penalties of speaking frankly is the risk of being misunderstood, but I want to ask, how many utility operators know that they are getting the maximum amount of heat for $1 in buying coal, and the maximum heat from it after they buy it?

In some plants a fireman is looked on as a coal shoveler, nothing more, and in some plants the engineer is a man who starts and stops the engine. It takes some thought to spend and burn ten or twenty or thirty thousand dollars worth of coal a year and do it right, and if the operator can save 5 or 10 per cent or more he is worth more in proportion to what he saves.

In water works expense what is the big item? Let me refer to a list of detailed operating expense compiled by the Wisconsin Commission covering eleven cities. See Table II.

TABLE II.—WISCONSIN MUNICIPAL WATER UTILITIES. CLASS A—DETAILED AND TOTAL OPERATING EXPENSES, IN DOLLARS, PER MILLION GALLONS PUMPED FOR YEAR ENDING JUNE 30, 1912.

	Million gallons pumped.	Total pumping.	Total distribution.	Total commercial.	Total general.	Total undistributed.	Total operating expenses.
Average	1,495	20.94	6.53	1.85	6.05	.89	35.32

Where is the big item? The total operating expense averages $35 per million and the total pumping is $21 per million, or 60 per cent of the total. Now I'll venture to say that one can analyze most of his costs down to a penny on most of these items, and perhaps some can give the amount of water pumped per pound of coal, but can you give and do you keep regular track of your engine efficiency, boiler efficiency, and furnace efficiency? I'll venture not one in twenty can give these last, and I venture to say that in January the majority took inventory, examined statements and scrutinized all items of expense, especially if earnings were not up to expectations. But how many of you know whether your coal or steam costs or other costs gave the proper relation to your finished product—be it gallons of water, kilowatts or heat?

How many pounds of water does that boiler of yours evaporate per pound of coal? Do you ever turn the hose on the ashes to see if they turn black? Have you tested your boiler? Have you tested your furnace and setting lately for air leakage or CO_2? Is it giving 4 or 10 per cent, or what?

Have you any check on what your engine, pumps, or turbines are doing? Have you an indicator, a steam water or recording meter in your plant? I'll say not many have.

Now if you had a store with clerks selling goods, would you have a cash register? I'll say you would, and if you didn't have you would get one quick the first time you found a few nickels unaccounted for. Well then why not buy efficiently, and run efficiently? Make your employes get all they can out of your equipment. Running expenses never stop for breath and the sooner you get them where they belong the better off you will be.

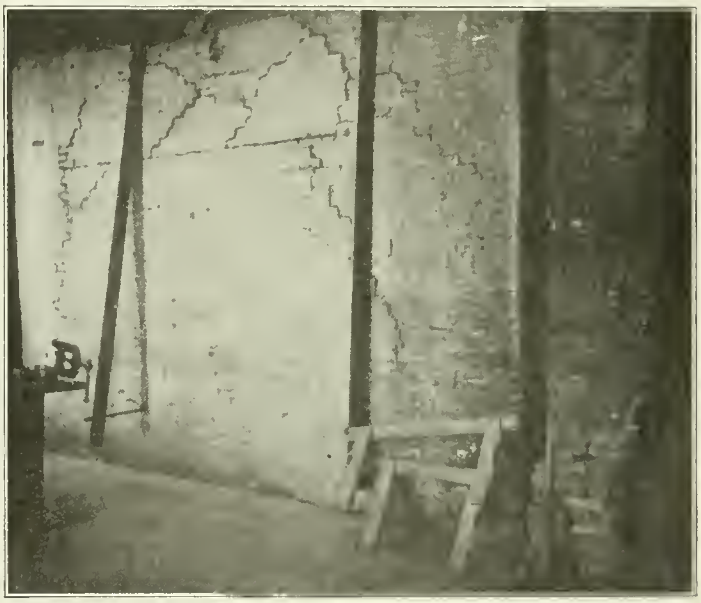


Fig. 7—Illustration of a Common Reason for Low CO_2. Excess Air Leakage Caused by Cracked Brick-work in Boiler Settings.

Now as to recording gages. How can they save coal? Take a plant where the demand for steam fluctuates or where the fireman is lazy and the safety valve will work overtime. Of course, a valve popping off once does not lose much heat, only about 1,200 heat units per pound at ordinary pressures, but if this goes on many times a day, and for each day in the year, you will find it will total to something. Instance one plant the writer had in charge. Before putting on recording gages the pressure varied all the way from 80 to 160 lb. and always popping. After putting on the recording gage the fireman kept it within a few pounds of 150. Furthermore, trouble in governing a large pump was overcome.

Are your boilers clean and all brick work tight and without leaks? Is baffling tight and gases not short circuited in water tube boilers? Are you using the proper draft for best working conditions, and do you use your dampers instead of the fire and ash doors, thus preventing excess air leaking? Are your draft regulators properly set? Are the combustion chambers of boilers clean, also tube spaces and breeching not stopped up with soot or ashes? Are all exposed pipe and heating surface covered properly? Are blow-off valves tight and not blown off excessively? Is the feed water heater clean and giving maximum temperature? Are all wastes, steam traps, etc., tight and without excess leakage? Does your engineer or fireman know you demand maximum efficiency and watchfulness, and do they keep a log and understand what the log means? Is there any great loss of pressure between boiler and engine? Is the steam dry? Are engines and pumps operating at maximum economy? Do pistons leak or are valves properly set? Have you indicated these lately? Is there excessive slip to the pump? Is exhaust back pressure at the minimum? Are you getting maximum or proper vacuum from your condenser and maximum hot water to hot well?

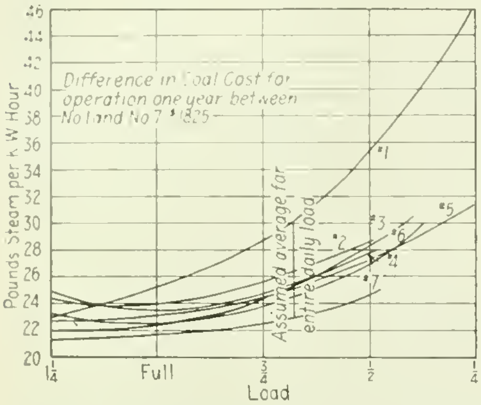


Fig 1

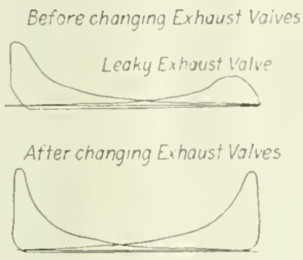


Fig 5

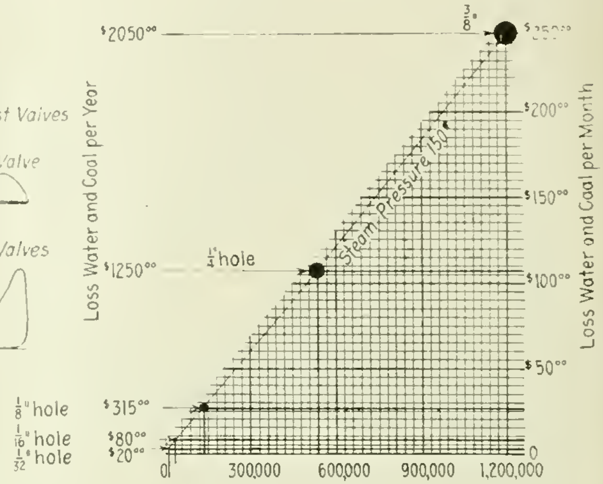


Fig 4

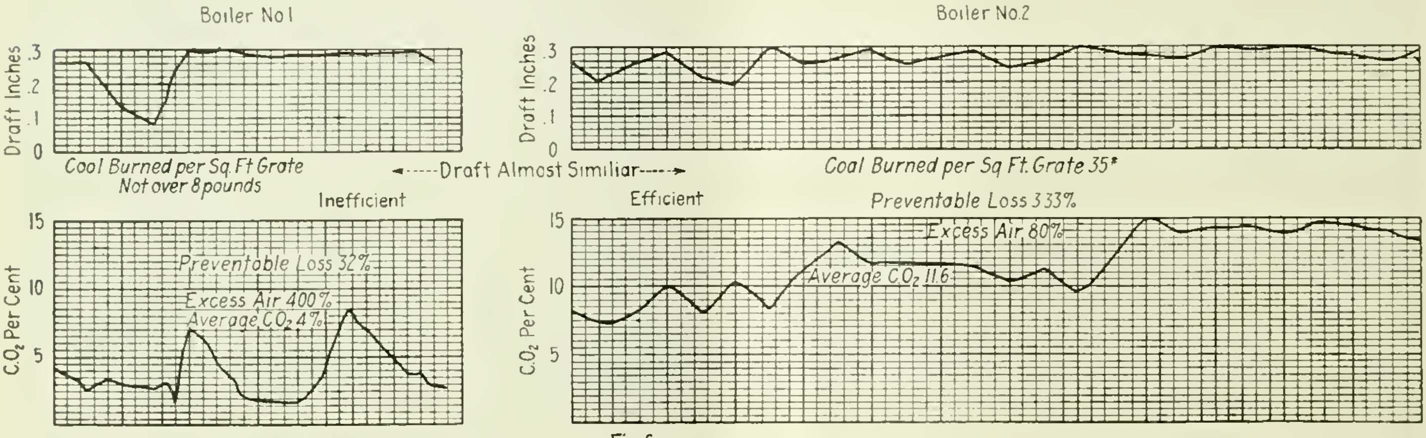


Fig.6

SOME MISCELLANEOUS DIAGRAMS PERTAINING TO EFFICIENCY IN THE PUBLIC UTILITY POWER PLANT.

Fig. 1—Turbine Steam Consumption per Kilowatt-Hour; 150-lb. Steam Pressure; 28-in. Vacuum. Fig. 4—Losses Due to Leaky Blow-off Valves. Coal Assumed at $2 a ton, 13,000 B. T. U. Water at 5 ct. per 1,000 gal.; Continuous Service. Fig. 5—Indicator Cards from 22x44-in. Corliss Engine Before and After Changing Exhaust Valves. Fig. 6—Diagrams Showing Comparison of Furnace Conditions and Efficiency of Two Boilers.

Do you know how much scale you have in your boilers and that you are operating with the least amount of scale? Figure 2 is a chart which will give an approximate idea of fuel loss due to scale. For example, ⅛-in. scale will make a difference of about 15 per cent on fuel increase. For instance, ⅛-in. hard scale and coal at $2 a ton and using 10 tons per day will mean a loss of about $1,000 per year in coal.

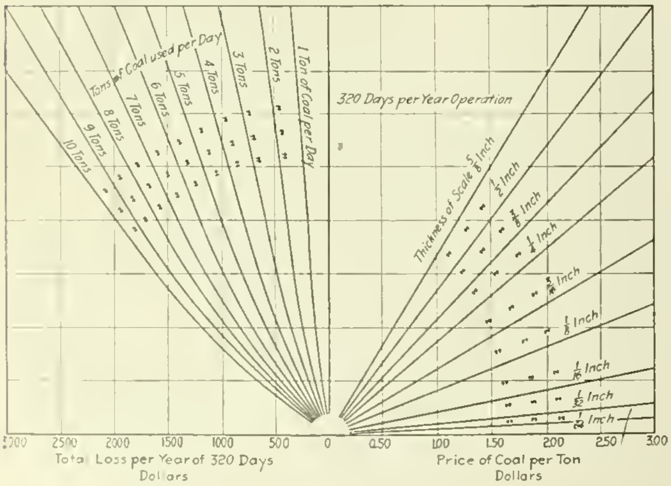


Fig.2

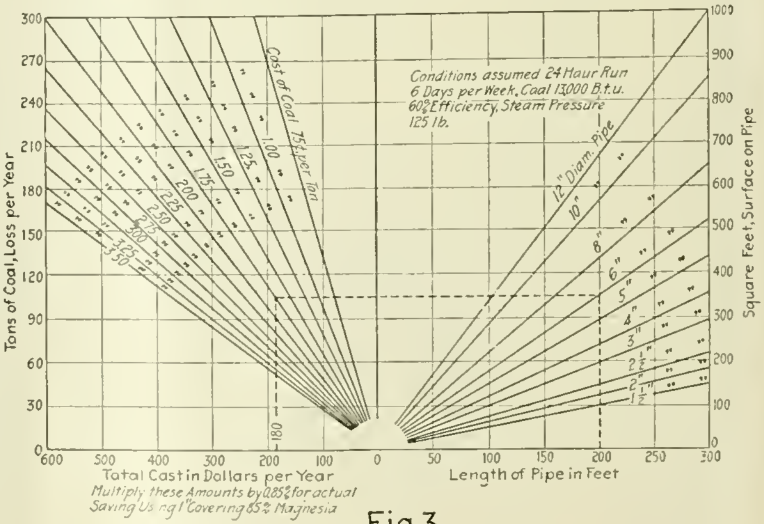


Fig.3

CHARTS SHOWING LOSSES DUE TO SCALE AND UNCOVERED STEAM PIPES.

Fig. 2—Chart Showing Loss Due to Scale. Example—With coal at $1.50 a ton, and scale ½ in. thick, using 5 tons of coal per day means a loss of $1,000 per year. Fig. 3—Chart Showing Loss Due to Uncovered Steam Pipe. Example—With 200 ft. of 6-in. uncovered steam pipe, with coal at $1.75 a ton, means a loss of $180 per year; of this 85 per cent can be saved by covering.

Figure 3 is a chart showing losses due to uncovered steam pipe. Note that 200 ft. of 6-in. pipe uncovered and with coal at $2.75 per ton means a loss of $300 per year and 85 per cent of this could be saved with a proper covering.

One municipal water plant that I know of ran for years with all its steam lines uncovered and they had to haul all their coal, and only a short time ago they asked for a reduction in rates on lighting from a private company that supplied the city. Now why should they not clean house at their own plant and give the citizens the benefit of such savings?

Do you know what leaky boiler blow-off valves cost you? Losses due to leaky blow-off valves are shown in Fig. 4. Have you any way of knowing whether your blow-off valves leak and how much? Have you ever realized that a leaky blow-off on one boiler with a leak equal to a ½-in. diameter hole and leaking continuously, steam at 150 lb. pressure, good coal at $2 a ton and water at 5 ct. per 1,000 gal., means a yearly loss of about $300? Now if you have five boilers leaking there is $1,500 a year fuel loss, and if the leaks are smaller or larger the coal loss will be in proportion.

Look at the indicator cards in Fig. 5 from a Corliss engine. The writer was called in to see why they could not carry their lighting load. Look at the upper card, and you can see why the exhaust valve leaked. From 7 p. m. to 7 a. m. we worked cutting a new key way in a new brass valve stem that had been placed wrong by a local mechanic. You will note the lower card looks a little better and it resulted in saving quite a little steam and there was no trouble in carrying the load, and this was not a municipal plant either. Now it would not have taken long to have paid for an indicator at the rate that plant was wasting fuel.

In Fig. 6 are two sets of readings which I have taken from two different plants giving simultaneous readings of draft and CO_2. Under No. 1 the average CO_2 was 4 per cent, showing a preventable fuel loss of 32 per cent. This boiler was running with 400 per cent excess air and the fire was very light and not burning less than 8 lb. per square foot of grate surface. On No. 2 you will note the CO_2 averages 11 6/10 per cent, the preventable fuel loss was less than 3½ per cent, and there was only 80 per cent excess air. The coal burned averaged 35 lb. per square foot of grate. The draft on No. 2 will average not higher than on No. 1.

Now the lesson in this is that in boiler No. 1, the draft was out of proportion and entirely too strong, firing at long intervals and air leakage, and the grate surface not suitable for the coal.

In boiler No. 1 this plant for the entire year was not averaging over 50 per cent efficiency, and on boiler No. 2 the test showed it was close to 68 per cent. The boiler No. 2 was fitted with a damper regulator and on boiler No. 1 the damper was not bothered, so we see the question of draft regulation and method of firing is very important.

Figure 7 shows one reason for low CO_2; excess air leakage caused by settings as shown.

You may say that all this is overdrawn and all these things could not occur, but I want to say that they do occur, not all of them at their worst in every plant or in most plants—but in many plants; and they are not confined to the municipal plant alone, but to the private plant as well and in many plants a little of each of the faults make a big total or perhaps one or two losses are really bad.

You won't believe me when I tell you some of the things I have found in plants for public utility service and not all of these small plants either. Here are a few examples: Two different plants with two stacks connected at each end of the same breeching, each stack a different height and the operators wondering why they had poor draft; several plants without a bit of insulation on a pipe or boiler; plenty of them with leaky brick work; one with a surface condenser absolutely clogged up so it could not be used; one with a surface condenser thrown out because the operating engineer said it did not do any good; one with the feed water heater out of service because it was too much trouble to clean it; one using about 40 per cent excess chemical in the water softener, and reminding me of the old farmer who had been instructed to give his sick horse a teaspoonful of medicine every hour. "By heck," he said, "if a teaspoonful helps, two will be better." He gave her two and buried the old mare the next day. One with a damper regulator connected backwards so the boiler could not carry the load; another where changes to the draft damper cut the consumption 8,000 lb. per day; one where all the water was being pumping twice when a little pipe work would have given the same results with one pumping and a big saving in fuel; one big corporation making pipe changes without a plan, fitting pipe by the cut and try method, and so on and so on.

Many have not realized it but we are in the midst of revolutionary times. This has, strange to say, been going on gradually for a period of a decade or more. Many improvements and new inventions, some quite radical, have taken place in prime movers, generating units, boiler equipment and methods of operation. Coincident with available improved economy in power plant work has been the revolution in thought leading to legislation and regulation of public utilities. The demand for lower rates has been more or less coincident with plant improvement, and increased efficiency of operation and management. And right here I wish to mention one instance of improvements in generating units: the 30,000 K.W. unit recently installed at the 74th St. Station, New York. As compared to the old Manhattan type engines which were installed in 1901, on 24-hour service, the new unit would effect an approximate saving of 240 tons or $700 per day, based on coal at $3 a ton.

Some utilities have seen the hand writing on the wall and have met modern demands half way or even more. Some have held aloof and when they have had to compromise on rates, have bent every effort afterward to bring their plants and equipment to a high state of efficiency, and have looked to new fields for extension (as in electrical power work).

It is an axiom of any business that is governed either by competition or some other tribunal of regulation, that profits must be fair, not exorbitant; otherwise, if a competitive business and profits are exorbitant the trade will go elsewhere. If not competitive, and subject to legislative correction, then legislative correction will be demanded.

A fair return should be assured on any utility—but, if any utility has not practiced economy, efficiency and good management it cannot help but react upon them, and if they have practiced it and have been able to avail themselves of more modern devices and methods, they should give the proper proportion of such advantage to their consumers.

I realize that there is some reaction against efficiency, especially as related to industrial improvement. In a number of instances it has been over done and so much has been made of system that it has become more burdensome and expensive than the gains warrant. But this is not the case at all, as related to the subject on which I write. Call it good management or any other name if you will, but bear in mind that to operate indefinitely in competition, or under legislative control, you must adopt in every branch, methods which replace inaccuracy with definite and accurate knowledge, you must systematically eliminate all economic waste and bring all departments into proper and harmonious co-ordination.

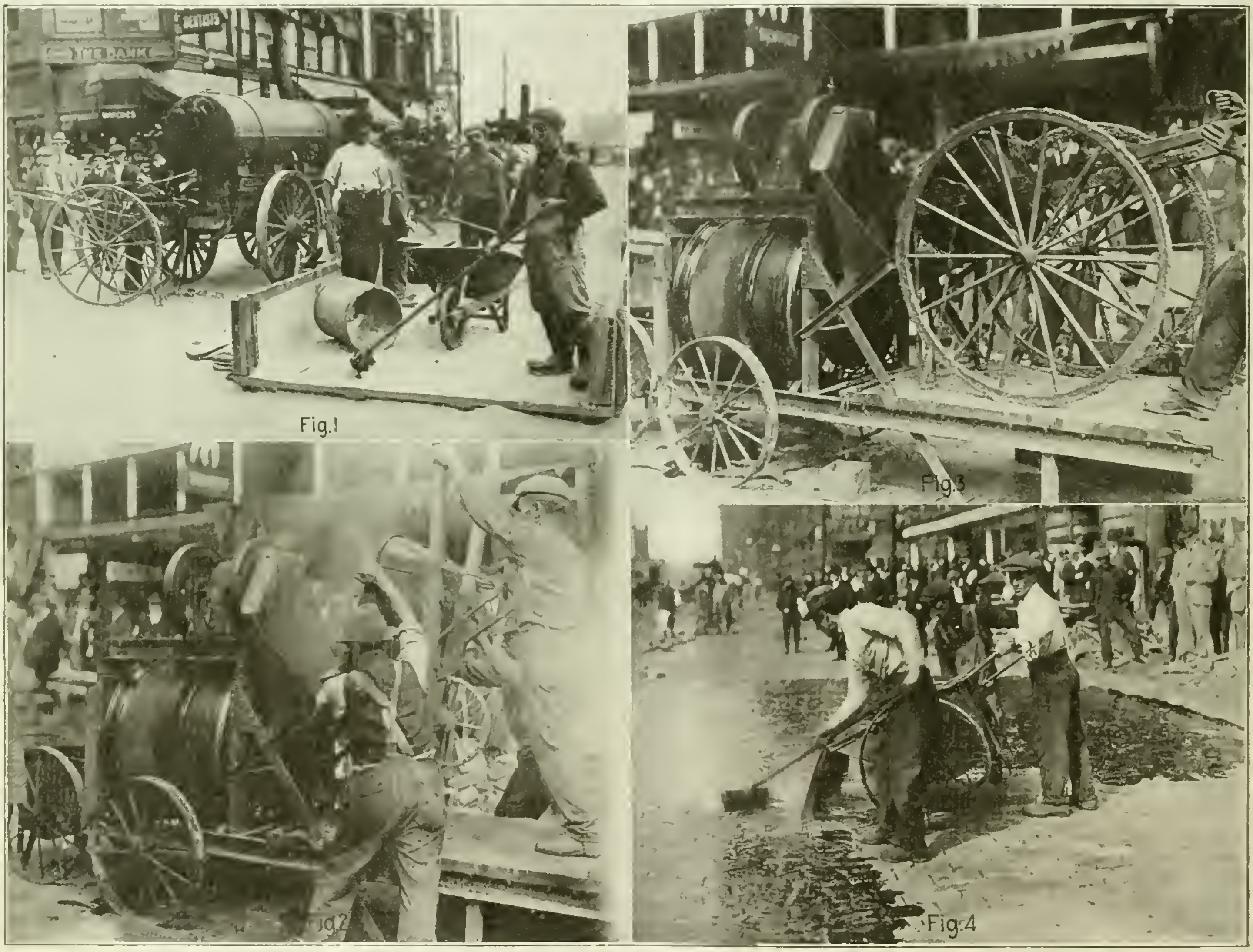
Efficiency in the Utility plant or in any branch of it means constant watchfulness, vigilance and the using of good, sound judgment in practical as well as technical matters and the difference between a plant operating or not operating by such methods may mean a matter of profit or loss—success or failure.

I believe the question of efficient utility management should in a measure and with proper limitation come under the jurisdiction of the state. If money is being needlessly wasted it eventually reacts on the consumer or taxpayer; it makes no difference whether it is wasted in improving streets, buying a road roller or purchasing material, machinery or coal for a power plant. The utility that is wasting money due to inefficient management, whether it be because the managers don't know, don't care or whatever the cause, should be told as much. After being brought to a state of efficiency plants should be kept there by proper suggestion and supervision.

METHODS OF APPLYING BITUMINOUS MASTIC FILLERS FOR BLOCK PAVEMENTS.

By John S. Crandell, The Barrett Co., New York, N. Y.

For many years the standard filler for granite pavements consisted of partially filling the joints with hot gravel over which was poured hot pitch, then another layer of gravel filling the joints to the top, followed by a seal coat of pitch. It was supposed that the hot pitch would find its way through the first layer of gravel, and that it would fill all the voids; the second layer of gravel would be similarly filled by the seal coat, and so the joints would be filled with a tar and gravel mixture of homogeneous character. In very few cases was this satisfactorily accomplished. If the gravel contains any fine material, like sand or clay, pitch does not find its way through, but merely forms a layer of itself, so that when an old pavement is opened an observer will often notice from the bottom to the top distinct layers of pitch and gravel.



FILLING STONE BLOCK PAVEMENTS WITH BITUMINOUS MASTIC, CLEVELAND, OHIO.
Fig. 1—Plant Used; Sand Platform, Tank Wagon, Pitch Cart, Mixer, Sand Measure. Fig. 2—Charging Heated Sand Into Mixer. Fig. 3—Charging Hot Pitch Into Mixer. Fig. 4—Flushing and Squeegeeing Mastic Into Joints.

The early part of the present century John A. Brodie, City Engineer of Liverpool, England, began to experiment with a matrix or mastic composed of hot pitch, cut back with creosote, and hot sand, the mixture to be used for grouting broken stone pavements. From the successful grouting of broken stone with pitch-sand mastic it was a natural step to try this matrix as a filler for stone block. This was done by Mr. Brodie in his Liverpool stone set pavements, and was brought to this country by Mr. Henry Welles Durham at the time that he was Chief of the Highway Bureau, Borough of Manhattan, New York city.

In the New York work the pitch is brought to the street in tank wagons and blown by air pressure into pitch kettles. The kettles are equipped with thermometers required by the specification. Sand is heated on the street in the usual plate heater, or is got hot from a sheet asphalt plant. The pitch is brought to the pourers in carrying buckets and poured into the pouring buckets, filling them about three-eighths full. The sand is brought in wheelbarrows, and is shoveled into the pouring buckets that have the pitch in them, whereupon it is stirred by slotted iron paddles. The buckets are designed so that the mixture comes from the bottom only. The proportion of pitch to sand has varied on different jobs, but is estimated as about 3 parts pitch to 1 of sand.

The success of this mastic filler having been assured for stone block work it was next tried on brick. The first pavements were poured, in imitation of the New York pavements, but it was soon made manifest that some quicker and surer method of filling the close joints of a brick pavement must be found. It was suggested that a mechanical mixer be used, making batches of mastic which should then be flushed on the surface and squeegeed into the joints, just as is done with cement grout. This was first tried on a brick road in Cuyahoga County, Ohio, near the city of Cleveland, in April, 1915. It resulted so satisfactorily that it was next tried in Columbus, O., not only for brick, but also for an experimental stretch of Durax.

The addition of sand to any bitumen tends to stiffen and toughen the material, very much as flour added to water or milk makes dough. The more flour that is added, beyond a certain amount, the tougher are the biscuits, the more brittle are the cookies. By adding too much flour we could concoct a dough that would fall to pieces

---

*Extracts from a paper read before the Indiana Engineering Society.

at the touch, and in like manner we can add so much sand to our mastic that it goes to pieces under traffic. It is a matter of experimenting to determine what proportions of pitch and sand to use; and just as a cook will complain that one barrel of flour does not knead as well as another, just so one load of sand may differ in its action with a bitumen from another. With this in mind experiments were undertaken to determine the best kinds of sand to use.

From these tests it was shown that the greater the per cent of sand the less liable it is to settle out; that is to say, a mixture of 50 per cent sand and 50 per cent pitch is not as liable to have the sand settle out as a mixture of 40 per cent sand and 60 per cent pitch. The temperature at which the mixture is made has a great deal to do with the settling. At 250° F. the settling is much less than at 300° F. The degree of fineness of the sand was also shown to be a factor in making a good mixture. Some samples were saved of the sand recovered from the mixtures, and these show that the fine sand is at the top while the coarse sand has settled to the bottom. The samples made with limestone dust show that this does not settle out, and makes a very good material to mix with pitch. This is due to the fineness of the material. While the 50-50 per cent pitch-sand mixture had the lowest slide it also had the highest breaking point.

The results obtained from these laboratory experiments seem to indicate that a finer sand than that used in New York would give very much better results than have been obtained so far. A fine seashore sand like that found at Coney Island, or a lake sand such as is found along the shores of Lake Michigan, would be excellent for the purpose.

In Cleveland, O., the method previously employed for filling brick pavements is being employed for filling Medina stone block pavement.

Pitch was brought to the work in tank wagons, and at the right temperature. The tank wagons were equipped with fire boxes so that the pitch could be kept at any desired heat. Sand was brought hot from a local sheet asphalt plant, and was dumped on a wooden platform where it was covered over with heavy canvas. The temperature of the sand was about 350° F., while the pitch was between 250° and 300° F. The mastic was mixed in an ordinary 3-ft. concrete mixer of the batch type and no provision was made for heating it other than putting in a preliminary batch of hot sand at the beginning of the day's work. The sand was allowed to revolve in the mixer for about 10 minutes while the drum heated up, after which the sand was run out and a fresh batch was run in. At the end of the day another batch of clean sand is run through the mixer to clean it out. The sand is dumped into the mixer after having been measured out into the wheelbarrow. A measureful of pitch is then added to the sand and the two are allowed to mix for about 2 minutes. It is thought that by adding the pitch to the sand that there is less liability of splashing hot pitch on the workmen. The hot matrix is then run out of the mixer into the usual grout can on wheels, and it is then taken to the place on the pavement where it is to be applied. It is best to stir the contents of the cart well with a hoe or squeegee before dumping. Enough men should be ready with squeegees to push the mastic into the joints immediately it strikes the stones or bricks. The mastic will be seen to be extremely fluid even on cold days, and it runs to the bottom of the joints as rapidly as does cement grout. By thus flushing the material onto the street every joint is filled from the bottom to the top. There is no repouring necessary, for, if the work is done right, the second batch will be dumped on the same spot that the first was emptied on. The double purpose is here served of filling all joints that were not filled with the first batch, and as the second falls where the first had heated the surface it is not chilled. What is left of the second batch after the joints are full where the first was emptied is squeegeed ahead to the unfilled joints into which it runs, and the third batch is dumped there. Thus every batch prepares the way for the succeeding batch, and it is not necessary to return to fill up joints.

After the joints have been filled there will be found a thin layer of mastic over the top of the stones or bricks. If the squeegee men have worked rapidly this should not be over 1/16 to ⅛ in. in thickness. A layer of slag screenings, pea gravel, or other suitable material should then be thrown over the surface of the street, and if possible a light tandem roller should roll the surface. If there is no roller to be had conveniently, then traffic may be admitted at once, and if there are any iron-tired vehicles passing frequently over the street they may be relied on to force the screenings or gravel into the mastic top, which will then resemble a tar macadam. A gang of eight men working like this will do more and better work than 20 working along the New York methods.

There is still room for improvement in the mixing of the materials. A more effective method of heating the sand should be devised, for the old-fashioned plate heater is not economical, nor does it get the sand hot enough on a cold day. Where sand may be obtained from an asphalt plant and brought to the street already hot a saving in labor may be effected, and a good grade of sand is assured.

FROZEN SOIL CONDITIONS AS AFFECTING WATER SERVICES.*

By J. B. Marvin, Consulting Engineer, Frankfort, Ind.

Each section of the country has established standards of depths for laying water mains and service pipes, the result, largely, of years of experience. Speaking from quite an extended experience, as well as from the practice of others, it can be asserted as a fundamental that iron water conduits of all classes must be laid at a depth to which frost will not reach, as iron is an excellent conductor of cold, and it becomes a safe rule to follow established and customary standards on depths in laying water mains and service pipes. It has, no doubt, been the experience of many that standards fail, that laying water mains or service pipes to any customary depth will not insure perfect safety from freezing. Much depends upon the character of the soil and exposure, either of which may produce unfavorable consequences, and either of which requires careful handling. As applied to depths, I am unable to state authoritatively just what class or nature of soil yields most readily to the action of frost. From an experience that I have had a service pipe, including corporation cock, froze at a depth of 42 in. In this particular instance the soil was hardpan, and was in the street where there was a considerable cut; the street sloping to a severe west exposure, and the freezing occurring after long and continuous cold weather. The main was 6-in. cast iron, the corporation connection being made on the top of the main. The main was not affected by the freezing. This occurred in the water works system at Frankfort, Ind., where most of the incidents that I will relate have taken place.

The water mains, in this plant, were laid with a 4-ft. cover; the service pipes with 42 in. The records show that in 30 years there has not been a frozen main and not to exceed five service pipes and, it may be added, there is of record at this time, in this plant, a short section of main with only an 18-in. cover, and others of much less than 4 ft. The less depth is accounted for by changes of street grade, in making street improvements, and by some inadvertence a failure properly to lower the main. This main was laid 30 years ago at the standard depth, the change of depth having been made when the street was improved 20 years ago. The size of the main is 4 in. It is of the original installation and is in a part of the city where only a small quantity of water is used, so a failure to freeze is not accounted for by active circulation. The original mains of this system of the 10, 8, 6 and 4-in. sizes were wrought pipe lined and laid in cement; this being one of that type of mains may account for its immunity from freezing.

---

*Paper before annual convention of Indiana Sanitary and Water Supply Association.

From experience I am prone to favor the use of a fire hydrant with a frost case. I have seen numerous hydrants with the frost case raised 10 in. after the freezing and thawing of several winters, and have had them lowered, when a recurrence would take place. Even if the barrel of a hydrant tapers towards the top, in the absence of a frost case, would not more or less strain take place and often cause damage to the hydrant? Then, again, might some benefit not arise from the air space between the barrel of the hydrant and the frost case, by higher earth temperature radiated from below the frost line? Of course, higher temperature would not be needed if the barrel of the hydrant was free from water, as it is intended that it should be, but which all too frequently is not the case. And that leads me to speak of the cause of this distress with fire hydrants. The most prolific cause of water in the barrels of fire hydrants is not from leaky valves, but from seepage through the waste holes where hydrants are located in low lands of a marshy nature, or at almost any place in certain characters of soil on occasions of long-continued rains. Of course, a trouble of this kind can be obviated by connecting the waste to a drain, but I am sure it would generally be agreed that such a method would be quite impracticable in most cases on account of cost. Since operation costs chargeable to fire hydrants are very much augmented in winter largely by the last cause mentioned, is there not to be some improvement that will obviate this trouble?

Consider the effect of frost on meters set at the curb or in meter boxes outside of buildings. Since it is a foregone conclusion that there is but one just and equitable method of selling water, and that is by measure, the meter and its setting become more and more important factors to consider in water plant construction and improvements as well as management. For many reasons it is desirable to set meters in housings at the curb, for convenience if nothing else, but for economic reasons also. In my experience a common method of setting meters in a 42-in. trench is to use an ordinary 18-in. sewer pipe and a cast iron cover, using risers that set the meters within 8 in. of the top of the box. No general trouble from freezing has been experienced from this method of meter setting until the very recent cold weather, when from a new or unusual combination of atmospheric and earth temperature conditions a vast amount of trouble occurred. While the temperature was sliding to zero meters heretofore seemingly immune were locked tight by frost almost at a time when they were being used. To account for all of this is the question. The severe cold weather was for only a few days' duration; the ground was frozen only to a varying depth of 4 to 8 in. There was an exceptional combination of differences, which possibly might account for the unusual results. Heavy rains had fallen for many days, 16 in. of snow which had covered the earth melted with the rainfall, much of the precipitation and melting snow was taken up by the earth. A sudden change of temperature took place; the mercury dropped from 64 to 3° within 8 hours. The cold continued for almost a week, within two days the trouble developed; complaint from services, suddenly stopped, revealed frozen meters in numbers heretofore unthinkable. The meter boxes resembled small stalactite caves, so full were they of hoary hanging frost. How do you account for it? Did the moisture in the earth chill the ground to a greater depth than is usual, and thereby prevent a sufficient amount of earth radiation to hold the air space in the meter box to a temperaure above freezing?

SOME HINTS ON THE DESIGN AND OPERATION OF INTERMITTENT SAND SEWAGE FILTERS.

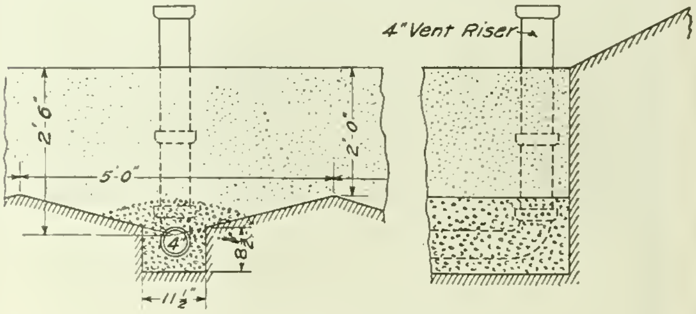
The treatment of sewage tank effluents on intermittent sand filters is very common in the State of Iowa. Consequently a special study has been given in that State to the design and operation of filters of this class. The notes here given are taken from Bulletin No. 16 of the Engineering Extension Department of Iowa State College, entitled: The Operation and Care of Sewage Disposal Plants. Mr. D. C. Faber, Industrial Engineer, is the author.

Sand filters should be made of clean, coarse sand. For satisfactory operation, the sewage must be applied to them in intermittent doses, and the surface of the sand kept in such loose and clean condition that the sewage will disappear entirely within a very short time after the application of each dose of the sewage. Sand filters will not work satisfactorily when the surface is kept flooded, as under these conditions the bacteria which effect purification cannot exist.

In sewage filters, the purification is effected by the agency of "aerobic" bacteria, or those which require oxygen to live. In the case of sand filters, the purification germs do most of their work at the surface of the filter.

When a sand filter is constantly kept flooded with sewage, the aerobic bacteria cannot live, because they have no means of getting oxygen. By applying the sewage in intermittent doses, which disappear after the application of each dose, air is drawn down into the pores of the sand as the sewage disappears and oxygen is supplied to keep alive the bacteria which cause purification. Hence, the surface of sand filters must be kept loose and clean.

Mr. Lafayette Higgins, engineer of the Iowa State Board of Health, recommends the construction of sand filters according to the accompanying diagram. Mr. Higgins states that the general idea of this form of filter originated at Iowa State College.



Form of Intermittent Sand Filter for Sewage as Recommended by the Iowa State Board of Health.

The construction shown provides for a clear depth of 24 in. of filter sand above the summit of the slopes which form the shallow valleys, the valleys being 6 in. deep. At the bottom of the valleys shallow trenches are made, in which are placed the under-drains. Under, around and over the under-drains is placed selected gravel of small size. At the head of the under-drains are placed suitable risers, extending 1 ft. above the top of the filters. A slow gradient may be given the under-drains by deepening the trenches toward the outlets of the drains. The under-drains, which are 5 ft. apart, connect into an interceptor drain of sewer pipe of rather large diameter, in ordinary cases, 12 in. These under-drains may be constructed of hard burned farm tile 4 in. in diameter, or of 4 in. sewer tile. In either case, the pipe should be in foot lengths.

Some engineers supply enough gravel entirely to fill the valleys. Other engineers have steepened the valleys greatly, some of which designs use a minimum amount of gravel, while others entirely fill the valleys. Other engineers carry the excavation uniformly over the entire bed and provide 6 in. of gravel, under which gravel the under-drains are placed, usually in trenches. Such designs usually require 24 in. of sand and 6 in. of gravel, plus the gravel under and around the drains.

The design as shown provides for 3,811 cu. yd. of sand and gravel per acre, of which about 530 cu. yd. are gravel. If an average depth of 6 in. of gravel be provided as a base for 24 in. of sand, and the under-drains laid 5 ft. apart in trenches with gravel beneath and around the drains, such gravel will amount to about 1,130 cu. yd. of gravel per acre. There is, therefore, a difference of 600 cu. yd. of gravel in these two methods. Part of the extra cost thus incurred would be offset by the release of the labor of grading the valleys in the bottom of the filter beds, but there would remain an excess cost which should be avoided in most cases.

Suitable sand for intermittent sand filters has been variously specified by different engineers. Some specify a clean, coarse, sharp sand, and again there are some engineers who simply specify clean sand. There seems to be one point of agreement, and that is that the sand should be clean, although this requirement has not been made for many years, and many failures of filter plants have been partly due to the fact that the sand used contained a considerable percentage of silt. The State Board of Health has given the matter of choice of filter sand a great deal of attention, and should be consulted concerning the suitability of any proposed sand, either for new filters or for replacement in old ones.

The gravel used in the bottom of the filters surrounding the under-drains prevents the sand from entering the under-drains and assists in the aeration of the beds. Evidently very coarse gravel is not suitable.

The usual size of filter bed is about 50 ft. by 150 ft., the number of such beds in any plant depending upon the amount of sewage to be disposed of. The sewage is distributed uniformly over the filters by means of distributors of sewer pipe, concrete or wood.

Filter beds constructed according to correct principles may be operated at rates varying from 100,000 to 150,000 gal. per acre per day, if properly taken care of. At present filter areas generally are calculated on the basis of one acre of filter for each 100,000 gal. of sewage per day. Results of experiments show that the most desirable dosing for filter beds with sewage which has undergone preliminary tank treatment, is sufficient sewage to cover an area equal to that of one filter to a depth of about 3 in. The rate of operation depends largely upon the amount of care which the filters receive.

A common cause of trouble is the overloading of the filter due to an increase in the amount of the sewage as the community grows, or increased use is made of the sewers. Additional filter beds must be added to take care of the increased amount of sewage, as soon as the original filters become overloaded. Increased operating care often can be made to take care of overloads, temporarily at least. As an example of this, the college plant recently has been working successfully at the rate of about 350,000 gal. of sewage per acre of filters per day. This was possible only by keeping a man continually on the job, who gave the strictest attention to operating details. As soon as cold weather set in it was found impossible to maintain this high rate, and the college experience is all against the wisdom of rates higher than 150,000 gal. per acre per day.

To secure satisfactory results, the surface of filter beds must be kept clean and open and practically level. Whenever sewage stands on the beds over a few minutes after dosing, indicating a temporary clogging of the surface, such clogging must be remedied. This may be done by breaking up the surface, ordinarily to less than 1 in. in depth. When such treatment no longer gives the desired result of rapid disappearance of the dose of sewage, it may be necessary to remove the scum, or deposit, formed on the surface and with it a small amount of sand. Such removal will usually total less than 2 in. per annum, but whatever the amount may be it must be removed. The proper care of filter beds requires the services of at least one intelligent workman for each plant, and more for large plants.

The operation of sand filters in the winter is more difficult than at other times. For one thing, the cold weather lessens bacterial activity to a certain extent, thus making it difficult to secure as high a degree of purification as in warm weather. As a matter of fact, it seems to be the general opinion that a high degree of purification is not as necessary in winter as in the summer.

In order to prevent the freezing of the sewage on the surface, thus sealing the filters and rendering them inoperative, filter beds are usually "ridged" for cold weather operation, so that when the beds are dosed the sewage flows in the gutters formed between the ridges. If freezing takes place the ice formed on the top of the sewage will remain suspended on the ridges and succeeding doses of sewage will flow underneath the ice. The ridges should be thrown up every 3 or 4 ft., and not be any higher than necessary to prevent freezing at the surface of the bed. At the close of the cold period the valleys between ridges must be freed from all deposit, or scum, before leveling down the ridges for warm weather operation. All dirty sand should be removed at this time, in order to keep the beds clean.

The effluent from a good sand filter, properly cared for, is clear and odorless, and has a very small percentage of bacteria left in it.

SOME SUGGESTIONS PERTAINING TO THE OPERATION OF WATER WORKS PLANTS.*

By John W. Toyne, Superintendent of Water Works, South Bend, Ind.

The operation of a water works plant is essentially a question of management, and in the present paper I have treated it exclusively from this viewpoint.

The management of any utility consists of two distinct features—the management of the physical plant through the utility's operating force and the management of the utility's business relations with its customers. This is equally true whether the utility is privately or municipally owned. Applicable, too, to both, are the several regulations recently adopted by the public service commissions in Indiana as well as other states.

The management of the physical features of a utility is an engineering problem, and I use the term "engineering" in its broader sense, which includes experience, sound judgment and the ability to build and maintain a loyal organization, as well as the essential theories taught us in the technical schools. Any one of these alone is good; all are absolutely essential in order to attain the most desirable results, and as in any line of endeavor really worth while there is no "royal road" to real success.

The questions that continually confront the manager of a utility are: Of what does my plant consist? What is its value? Of what is it capable? Is it rendering the highest possible efficiency? Is it rendering the best service possible? What provisions must be made to meet changing conditions? Is anything being overlooked that is essential? Does it pay?

I am afraid if we were asked these or similar questions a great many of us, at least, would experience some little difficulty in assuring even ourselves that we really knew the answer.

Is it sufficient, from the standpoint of the manager, to sum up one's palnt as so many acres of land, so many buildings, certain pumping machinery, so much power generating equipment, so many miles of distribution pipe lines, so many hydrants, valves, meters, etc., enumerating only the physical items? Does not the human element, the operating force, enter as largely into the makeup of a plant as its mere physical properties?

Given the best equipment, the most scientifically designed distribution system and an unfailing supply of water, and still your plant is sadly deficient if this feature has not been properly provided.

A knowledge of the value of the plant, not only in its entirety but by units, is essential in order that provisions may be made for replacements as well as a fair return above maintenance during their useful life. In my own work I have adopted the system of permanent unit inventory, showing for each unit, wherever possible, date of purchase, manufacturer, purchase price, cost of installation, probable life, depreciation annuity and present value. In a great many cases the compilation of an inventory of this character is a really formidable undertaking, owing to the incomplete and inaccurate data of record necessary, but once developed it is of inestimable value to the manager, even though frequent corrections or adjustments must of necessity be made.

Every manager cannot only well afford but cannot afford not to paraphrase Pope into "Know, then, thy plant"; not only its value, either its cost or appraised unit value, but its capabilities, the utmost duty that can be derived from each unit, the percentage load that will render the highest efficiency, taking into consideration the interest charge on the investment, the depreciation accruing and the continual advance being made toward more perfectly efficient machinery by the manufacturers. This can be determined only by actual tests intelligently conducted; and the results, to be of value, must be so compiled as to be available for comparison with performance data in operation, as only in this way can the operation be brought to even approximate the ideal.

---

*Paper before the annual convention of the Indiana Sanitary and Water Supply Association.

The standard by which everything must be measured is the service rendered; this applies not only to the service rendered by the plant to the utility, but by the utility to its customers. The service rendered the utility by its plant is governed entirely by the manager; by his ability to know his plant, to build and maintain an organization loyal to him and his aims, to derive the highest efficiency possible from his plant, to anticipate the demands of changing conditions and make the necessary provisions.

The determination of the value of the physical plant, together with the point of highest operating efficiency of each unit, represents but a small portion of the manager's work in securing the best possible service from his plant.

The work of building and maintaining a loyal organization is fully as important and requires infinitely more ability, judgment and application. It is, in fact, the test of the real manager, as the service rendered the utility by its plant is entirely dependent on this element. Personally, I have had no success with any form of organization having more than one head. This applies not only to the utility as a whole, but to each department and bureau, and in this connection one must always remember responsibility fixed cannot exceed the authority granted. To me, a bureau, department or utility with more than one head, a job with more than one boss, is as ridiculous as a two-headed hen.

In building his organization the manager must know the results desired, the qualifications necessary to get the results, and must be able to judge human values with this in view, otherwise he cannot hope to have a well-balanced, efficient organization. The manager's work is not completed with the building of his organization. To be of real value it must be maintained. It has none of the attributes of perpetual motion other than the constant expense. Its maintenance requires a world of tact, infinite patience, and, above all, absolute fairness, with a real knowledge of his physical plant, its value and possibilities with an operating force properly organized and thoroughly loyal; the service that can be commanded from its plant by a utility is limited only by the ideal.

The service rendered its customers by a utility is equally dependent on the manager, for the attitude of his operating force will be largely a reflection of his own. He must always bear in mind that his customers have a right to expect prompt service cheerfully rendered, as well as courteous attention at all times. Absolute fairness is as imperative in the manager's dealings with the customers of the utility as with his operating force, as in no other way can he build up a real "good will" asset.

Standards of service are being established by the several public service commissions. A great many of those prescribed have been exceeded for years by a number of the utilities. Others will, I believe, work a real hardship on the utilities without materially adding to the service rendered the customers of the utility.

Every manager is continually confronted with changing conditions, not only as it affects the physical plant but in the service requirements, the increase in population served, the extended area covered by his distribution, changes in direction of the city's growth; all these intimately affect the utility and must be anticipated by the manager if he would avoid serious embarrassment in serving his customers.

If a manager really knows his plant as outlined he will not only be in a position to know, but will know whether it pays, and how well.

In my own work I have found that a slight change in the method of firing saved tons of coal in generating steam; that apparently slight changes in piping prevent unnecessary waste of energy; that a careful routing saves hours of unnecessary labor in reading meters and delivering bills; that a division of the city into payment districts, while in no way reducing the service to the consumer, saves the utility approximately a thousand dollars per year in office labor.

In the item of permanent records of his plant, a manager can, through careful selection or development of forms and accuracy in their use, save much unnecessary labor and render better service. I have found card systems and loose leaf records more flexible and, consequently, more readily adapted to the requirements of a utility.

To sum up, the manager must be all things to his utility and his customers. He must always be in touch with his plant, with his operating force, with his customers and with his field of work in general, as no utility can exist for itself alone. There is a constant advance in equipment, methods and service, and only by keeping fully abreast can any manager hope to render the best service to his utility, its customers and himself.

EFFECT OF DIESEL ENGINES ON FUEL SUPPLY AND COST.*

By S. A. Hadley of the McIntosh & Seymour Corporation, Kansas City, Mo.

The Diesel engine has not been introduced into this country long enough yet for the effect of its remarkable economy to be perceived, though this economy has been proved and admitted. The cost of fuel, like everything else, is governed by the law of supply and demand, and Diesel engines will affect both.

The fuel supply of this country consists chiefly of petroleum and bituminous coal; natural gas and anthracite being sold now almost exclusively for house use are not affected much by the economy of the Diesel engines and will not be considered here.

The price of coal has increased about 1 ct. per ton at the mines each year in spite of increased production from 270,000,000 tons in 1900 to nearly 600,000,000 tons in 1915 on account of a demand which increased faster than improved methods of mining have cheapened the cost of production. Within the last six months the combination of an active demand a threatened shortage and sympathy with the rise in oil prices has made a sudden increase of 15 cts. per ton, nearly 11 per cent of the cost at the mine. It is believed that the cost of mining coal can not be further reduced as increasing difficulties will more than offset improved methods. There is no large margin of profit to be absorbed and so the industrial growth of the country means constantly increasing prices for coal.

The Diesel engine which uses oil fuel will produce a brake horse power on 7,500 heat units in the fuel. Steam plants which now use coal almost exclusively for fuel require an average of 50,000 heat units per horse power ranging from 75,000 for the common factory or central station plant of less than 100 HP. to about 20,000 for the best and most expensive large central station plants. Now much of the country is supplied with power by these smaller, less efficient steam plants where poor water supply or varying or insufficient load has prevented the installation of large steam plants of the better type. Here the Diesel engine can step in and make an immediate saving of about 80 per cent of the fuel, for it is nearly as efficient in small sizes or at half load as in large sizes or at full load and is not affected by a poor or deficient water supply. Several instances in Kansas can be shown where small central station plants have reduced their annual fuel bill from more than $2,500 to less than $500.

The Diesel engine is limited in size to units of about 100 B.-HP. and this might be thought to prevent it from competing with the large central station. To some extent this is true, but only in congested districts where power can be sold in large quantities with small distributing cost. There the coal fired steam plant of the latest design can produce the electrical energy at nearly as low fuel cost as with Diesel engine, because of the difference in the cost of heat units in coal and in oil. The investment in such a plant is nearly or quite as much as in the Diesel plant, being from $75 to $110 per kilowatt exclusive of land or transmission lines. The convenience of having prime movers equal to the largest individual loads may warrant the use of steam, but where users of power are scattered over wider territory and no one unit requires several thousand kilowatts as may be the case in rolling mill work or electric smelting, electro-chemical processes such as obtaining nitrogen from the air by electrical discharges, etc., the Diesel engine can compete easily with the coal fired steam plant. Instead of central stations of from 5,000 to 50,000 capacity with step up transformers, high tension transmission lines, step down transformers and in the case of electric railways, rotary converter sub-stations, there may be a number of Diesel plants of 500 to 2,000 HP. capacity each, equal to the sub-stations of the other system with generators producing current at moderate voltage, say, 2,300 to 3,300 in alternating current practice or 2,500 volts in the case of direct current railway systems, and all these stations tied into one another in parallel operation. The investment would be less, the attendance no more, the plants could assist each other in emergencies by raising the voltage enough for two adjoining stations to carry the load of one temporarily disabled or cut down for any reason, the whole system would be more flexible and the economy of the Diesel engine could be realized at all loads. This method is possible because the Diesel engine is more efficient in units of 1,000 HP. or smaller than the steam turbine plant in units of 25,000 HP. and because power is finally used in relatively small amounts over a wide area and by producing it closer to where it is used the cost and loss of distribution is reduced. With high tension electrical transmission from large central plants, it must be transmitted twice, once at high tension to the sub-station and again at lower voltages back over practically the same ground to the user. The cost of distributing oil fuel to scattered Diesel plants is slight because of the small quantity and the fact that it can be piped or shipped in tank cars.

---

*Paper before annual convention of Kansas Engineering Society.

The above system applied to railways would release an enormous amount of coal to meet other demands for railroads are the largest consumers of coal. Electric traction has other advantages besides the saving of fuel and is being adopted on a large scale now, by the Chicago, Milwaukee & St. Paul Railroad to its mountain divisions where water power is available. The reduction in demand for coal caused by increasing use of Diesel engines may not result in decreased cost, but will at least check the increasing price and will allow more coal to be used for coke making, smelting ore, and for industrial processes that will benefit by a continued supply at a moderate price. Powdered coal is now being generally adopted for burning clinker in cement kilns, for brick and tile kilns, open hearth furnaces, etc. Increased prices for coal would be felt by these products and by all iron and steel makers, which take nearly as much coal to make the coke smelting ore as do the railroads.

The production of coke furnishes a source of fuel for the Diesel engines in the oil that can be distilled from coal tar. In Germany this fuel is used in preference to petroleum fuel oil, which is imported duty free. In this country it has not yet become a commercial reality as so much tar is used in the crude state for roofing, road building, paving, etc., but when we begin to refine the tar to obtain aniline dyes, fertilizers and other valuable by-products this tar oil will be produced in quantities sufficient to have a regular market and being a by-product will be sold at low price.

The increased demand for oil fuel can not raise the price much, for the engine uses the cheap heavy grades of crude oil which have little value for refining and uses the residue after the gasolene and more valuable constituents have been removed. It is true that this by-product has risen in price lately almost 50 per cent more than its low price of a year ago and there has been more than a doubling of price of crude oil, but a little consideration will show that further increases will affect the price of gasolene and the lighter products only as they have no substitute.

The production of crude oil for 1914 was 290,312,535 barrels and for 1915 about 2,000,000 barrels more. There was a decline in the last half of 1915 of almost 100,000 barrels per day in the largest field, the Cushing, a decrease from the 1914 rate of 18,000,000 barrels, i. e., had Cushing kept its past rate the 1915 production would have been over 310,000,000 barrels. But this was the only field that decreased and many new wells were brought in and extensive new fields developed in Central Kansas and in Montana and it is expected these new fields will hold up production. The increasing demand which is raising prices is for gasolene and the heavy residue will remain a drug on the market except at prices which will compete with coal for boiler use in down town power plants and heating plants where its cleanliness and easy handling will allow it to be used at prices of from $1.25 to $1.50 per barrel and probably a little higher. At these prices the Diesel engine can produce power to compete with coal in the ways mentioned before.

It remains to be seen how much of this comparatively cheap liquid fuel is available. Without taking into consideration the fuel oil that can and, undoubtedly will, be produced from coal tar, the supply is very large. Formerly over 50 per cent and now about 20 per cent of the crude oil, from the mid-continent field is marketed as fuel oil, though there is a wide variation with different oils and different refining companies. A much larger percentage of California and Mexican oil is fit only for fuel. In 1915 the production of the mid-continent field was 152,869,680 barrels, which by modern methods of refining yielded about 30,000,000 barrels of fuel oil. California in 1915 produced 112,892,855 barrels yielding over 50 per cent of fuel oil or about 60,000,000 barrels. The total fuel oil supply for 1915 was 90,000,000 barrels. The above figures take account of modern methods of refining and by the older methods there will be much more fuel oil. There will probably be further changes in refining as the demand for gasolene grows. To offset this is the supply of Mexico which has just been tapped and is not now being imported at all in any considerable quantities. It is fair to assume that Mexico will at least supply enough to make up for a decrease in the production of fuel oil by improved methods of refining now unknown. It is a fact that the production of crude oil in the United States has increased steadily each year and that proved oil territory has widened. Some fields, notably the Cushing field, have fallen off in production but none, not even those, are exhausted. It may be taken as an indication of the steadiness of the supply that the Standard Oil Co. now have under construction 180 new stills in seven different refineries.

Any builder of Diesel engines, of whom there are now a considerable number of good repute, will guarantee a brake horsepower on less than half a pound of fuel oil. The annual production of 90,000,000 barrels means 60 billion horsepower hours, or 20,000,000 horsepower years of 300 ten-hour days each. This is the amount of power, now produced at an average of over 5 lb. of coal per horsepower hour, which can be had from Diesel engines, not taking into account the fuel oil from coal tar. It represents a yearly decrease in the demand for coal of 150,000,000 tons, one-fourth the present production, which will be that much added to our coal supply and will serve to prevent a rise in price. Our conclusion must be that the Diesel engine by its use of a by-product as fuel will defer the exhaustion of our coal supply and tend to maintain present prices and that without it there must be a considerable increase in fuel prices.

DRAIN COMMISSIONERS AND DRAINAGE ENGINEERS IN MICHIGAN.*

By A. D. Moorehouse, Drainage Engineer, U. S. Department of Agriculture.

The present conditions in Michigan warrant a more elastic and inclusive drainage law, not merely for the construction of "drains" but for the formation of drainage districts for the reclamation of wet lands by means of ditches, regulation of stream channels and stream flow, tile drains, levees, pumping plants, dams, reservoirs, sluices and controlling apparatus; for protection against floods; for drainage of highways, cities, and towns; as well as for all drainage work necessary for health or sanitation. This object can seemingly best be obtained by the enactment of an entirely new general State drainage law which will contain, so far as convenient, the procedure of the present law as to notification, publication, court processes, etc., inasmuch as the Supreme Court has established the constitutionality of the greater part of such procedure and those charged with the administration of the law have become thoroughly familiar with such details.

Drain Commissioners' Salaries.—Under the present system of county drain commissioners there is no uniformity in the salaries paid, and in many cases salaries are shamefully low. The position is one calling for a thoroughly capable man, possessed of more than the average intelligence, discretion, tact, and perseverance, and capable of hard work; as such, the "drainage" commissioner should receive a salary commensurate with those of the highest-paid county officers. It would be well for the law to set some minimum salary for the office. An engineer or a man of some engineering knowledge would be very desirable as an incumbent, as primarily all drainage problems are of an engineering nature.

State Drainage Engineer.—The standardization of drainage work throughout the State and the obtaining of the greatest results for the money expended is the greatest consideration. These objects would best be attained by the employment of a State drainage engineer whose office would be available for consultation on all drainage matters by the county drain commissioners and drainage engineers of the State. Also, when called upon, he should pass upon the plans of drainage districts, in which case his recommendations should be obligatory. He should formulate and simplify, so far as possible, drainage methods and procedure for the State. The sale of the drainage bonds would be greatly facilitated by the approval of such a State officer, even though they were not guaranteed by the county and State. In many districts the drainage work to be undertaken may materially affect the flow of the streams of the State with the possible danger of increasing flood discharge. The engineer of the district and county drain commissioner have local interests to conserve and their jurisdiction does not extend beyond the particular district. The State needs therefore a competent drainage engineer with authority to pass upon such matters—one who will have a thorough grasp of the large needs of the State in drainage and in flood prevention and control work.

Seemingly, drainage in southern Michigan in the past has been subservient to water power development, as testified to by the thousands of acres of marsh or other wet land impossible of drainage at present on account of the damming of the streams. In the design of drainage works it is often possible to protect or develop water power, especially in the larger streams, without detriment to the drainage reclamation undertaken. There are likewise possibilities of developing irrigation works which may prove of great value in the greater development of the trucking and special crop industry of the State. Such questions can only be satisfactorily handled by some State official vested with the proper authority.

---

*Extracts from a report to the Office of Public Roads and Rural Engineering.

PRACTICAL SELECTION OF AGGREGATES FOR CONCRETE.

Contributed by R. J. Borhek, Tacoma, Wash.

[The following notes on aggregates are merely a compilation of the writer's observations covering a period of 14 years' work in engineering and contracting. During the last three years the observations and tests have been made from the sand and gravel dealers' standpoint, the writer during this period having operated a pit to furnish to the U. S. Government materials for the Lake Washington Canal locks at Seattle. Engineers' and architects' objections of course had to be met, but by demonstration and encouragement along the lines suggested, a better grading of materials is now effected and much economy procured.]

It is not the intention of this article to deal with the hardness, angularity, roughness, roundness, or general fitness of any given aggregate. The aggregates are supposed to be clean and of such quality that the work at hand can be performed by properly combining them to get the desired result. The article is also based on the assumption that the reader has an intimate knowledge of the proper degree of wetness or dryness necessary to attain the best results; also that the dangers of inefficient mixing and placing of concrete will at times cause disastrous results, no matter how good the materials.

Sand.—It would not be amiss to state that the best sand (or stone) is that which has grains of all sizes present, such that the smaller grains fill the voids of the larger, the percentage of any particular size being only sufficient to fill the voids between the grains of the next larger. Sand is generally considered to be the finer aggregate, having grains ¼-in. diameter or less. Moist sand occupies more space and has more voids than dry or saturated sand, this difference ranges from 5 per cent to 10 per cent, and is entirely dependent on amount of moisture. The maximum size of sand grains can only be determined by the size and graduation of the large aggregate. The larger the aggregate, the larger the sand (the coarser sand). When we combine small gravel or stone 1 in., ¾ in. or less, with coarse sand ¼ in. to 1-20 in., we get concrete, "that's all." When we combine 1 in., ¾ in., etc., aggregate with fine sand graded through all sizes (⅛ in. max. size) down to the finest, we get maximum strength and maximum density. The smaller the coarse aggregate the smaller the sand grain.

The best sand for 2½-in. stone varies from 1/3 to 0.-3 meshes per lin. inch.
The best sand for 1½-in. stone varies from 1/5 in. to 0.-5 meshes per lin. inch.
The best sand for 1-in. stone varies from 1/6 in. to 0.-6 meshes per lin. inch.
The best sand for ¾-in. stone varies from 1/10 in. to 0.-10 meshes per lin. inch.
The best sand for ½-in. stone varies from 1/14 in. to 0.-14 meshes per lin. inch.

This can readily be established by trial. These sand sizes mixed with graded stone of above-mentioned sizes will give least volume, maximum density, greatest weight per cubic foot. After you have once established this fact, use all the cement necessary to attain the required strength. Sand cement tensile tests are not a true index to the compressive strength of concrete, unless we grade the sand to the size necessary to give maximum density for the coarse aggregate to be used.

Now take up the large aggregate, which we will consider as gravel. The same distinguishing line will have to be drawn as to what constitutes gravel.

2-in. to 1/4-in. graded gravel has an average of 33% voids
1½-in. to 1/5-in. graded gravel has an average of 35% voids.
1-in. to 1/6-in. graded gravel has an average of 37% voids.
¾-in. to 1/10-in. graded gravel has an average of 40% voids.
½-in. to 1/14-in. graded gravel has an average of 45% voids.

You cannot combine small gravel 1 in. or less with sand, no matter how you grade it and get so few voids, so heavy a mixture, so dense a mass, as when you use the larger size gravel. The reason for this is you cannot get the proper graduation of sizes, and on account of the displacement of the finer particles due to the large sizes of gravel. For maximum density your proportion would be for the different sized stone, considering sand ¼ in. and under—

2-in. stone graded to ¼-in., 33% sand.
1½-in. stone graded to ¼-in., 38% sand.
1-in. stone graded to ¼-in., 47% sand.
¾-in. stone graded to ¼-in., 54% sand.
½-in. stone graded to ¼-in., 66% sand.

One very common failing is when small gravel or stone is used the sand is too coarse or else not enough of it is used. The voidage in fine gravel or stone, even though the grading be scientifically correct, cannot possibly be as low as when a large graded aggregate is used.

The reason for the denser and harder concrete is this: The coarse particles having a larger volume displace a large proportion of the fine, thus affording an excess of mortar.

We might illustrate this by comparing the volumes and surface areas of particles of different sizes and diameter. The argument will at once be brought forth that the gravel particles are not perfect spheres. That is true enough, but consider also that a 2-in. diameter sphere is equal in volume to two ellipsoids having a 2-in. long axis by 1-in. short axis. Choose any other figures approximately the shape of a particle of gravel, spherical sector, segment or zone, measure up the actual surface area by forming a plastic mould around same, planimeter the area and you will conclude that the average gravel particle passing through a given size screen approximates a sphere in volume and surface area. Now, with this assumption proceed as follows:

In volume 1 particle 2 in. in diameter equals 8 particles 1 in. in diameter. In surface area 1 particle 2 in. in diameter contains one-half the surface area as the 8 particles 1 in. in diameter. Theoretically it would require but one-half the amount of mortar to cover the 2-in. particle as it would to cover an equal volume of 1-in. particles. In practice this is not quite true because of the voids in the volumes of smaller particles, and also because the particles are not perfect spheres.

By actual practice and a measurement of densities of a mass of sand and gravel it is absolutely established that the volume of 1-in. particles cited in the above case will require 1⅓ times more mortar than the volume of 2-in.

For a comparison: determined by actual measurement:

1 cu. ft. 1½-in. gravel has 1.15 times the surface or contact area of 1 cu. ft. 2 in.
1 cu. ft. 1-in. gravel has 1.3 times the surface or contact area of 1 cu. ft. 2 in.
1 cu. ft. ¾-in. gravel has 1.75 times the surface or contact area of 1 cu. ft. 2 in.
1 cu. ft. ½-in. gravel has 2.00 times the surface or contact area of 1 cu. ft. 2 in.

One reason for the excess of mortar required is plainly seen. One reason for the more cement required is established. The advantage gained by using the largest aggregate possible for reinforced concrete work is very evident. You have less surface contact, more bond adhesion, and stronger concrete.

The arguments brought against the use of the larger aggregates will be: Honey combing and pocketing, can't be done. The objection can be dismissed on the ground that in intelligently mixed and placed concrete, pocketing and honeycombing do not occur.

Two-inch aggregate can be used in 12-in. columns and 8-in. beam, the large gravel is merely displaced by the finer gravel and mortar, and when properly agitated will always flow into place. What do you care whether you have 2-in. aggregate in the core of a 12-in. hooped column or whether the finer material flows to the outside to act as a protective coating? Concretes richest in cement are least permeable. Measure the permeability of neat cement. Measure the permeability of 1 to 1 mortar. Measure the permeability of 1 to 2 mortar. The 1 to 2 mortar is about 100 per cent more impermeable than the neat cement and about 50 per cent more impermeable than the 1 to 1 mortar.

Measure the permeability of neat cement, of 1-1-1 concrete, and of 1-2-5 concrete. The 1-2-5 concrete is 100 per cent more impermeable than the neat cement and about 40 per cent more impermeable than the 1-1-1 concrete. The permeability of concrete is much influenced by grading of aggregate, particularly the sand. Using the same gravel and sand a 1-2-7 concrete is more impermeable than a 1-2-4, and this can be demonstrated, even with a poorly graded and fine sand.

In considering mortar—mortar to be permeable should contain a large percentage of fine sand, sand below No. 50 and nothing above No. 20. A coarse sand mortar is not nearly so impermeable as a fine sand mortar. Crushing gravel does not add to the strength of the concrete. Crushing merely increases the voidage due to the angularity of particles. Tests in crushed gravel 1½ in. to ¼ in. showed an increase of voidage for 35 per cent natural material to 42 per cent for crushed.

Graded crushed stone weighs less than graded natural gravel, the specific gravity being the same. Why? More voids. The particles of crushed stone are more nearly cubical than the gravel—more surface area (more contact area)—more voids.

Crushed limestone 1¼-in. to 1/20-in. voids 37% weight 98 lb. per cu. ft.
Crushed granite 1¼-in. to 1/20-in. voids 41% weight 95.3 lb. per cu. ft.
Screened gravel 1¼-in. to 1/10-in. voids 33% weight 102.4 lb. per cu. ft.
Crushed limestone 1-in. to ¼-in. voids 45% weight 85 lb. per cu. ft.

A roughened and pitted gravel has the same adhesion for cement as that of crushed stone. Some river gravels on account of the smoothness, particularly quartsite pebbles, which are not only smooth, but hard to wash free of slimy accumulation, are not as good as crushed stone of the same hardness. The advantage of using gravel over broken stone is that gravel concrete works smoother (flows easier) and is more dense.

The writer would suggest that in analyzing sand for concrete purposes, sieves of 4 mesh, 14 mesh and 40 mesh be used, 100 per cent to pass No. 4, not more than 70 per cent to pass No. 14, not more than 30 per cent to pass No. 40; this would assure a grading having enough sizes present to give an excellent mortar.

VARIOUS METHODS OF DRAINING RAILWAY ROADBEDS.*

By M. C. Blanchard, Engineer Eastern District, Atchison, Topeka and Santa Fe Railway, Topeka, Kans.

The importance of proper and adequate drainage for railway roadbeds has always been realized, but the rainy season of 1915, due to its length and the great precipitation that occurred, has served to emphasize that fact to those actually engaged in the maintenance of track.

Ordinarily the usual methods of drainage, such as cut and surface ditches, when properly maintained are sufficient to carry off the surface water, and provide a fairly well drained roadbed. Frequently conditions occur, however, when these ordinary means are inadequate, and it is then necessary to provide special means or systems of drainage to carry away the water which sinks into the roadbed.

The condition most common requiring these special systems is the formation of a pocket or bed of porous material of considerable depth, underlying the track, into which surface water sinks and is imprisoned to a greater or less degree by the adjacent earth. This condition occurs in both cuts and fills and usually is brought about in the following manner:

In cuts the ditches frequently become blocked by dirt which washes or slides in from the sides. The surface water is thus prevented from escaping and gradually sinks into the roadbed making it soft and spongy. Occasionally this same condition is caused by springs or seepage which occur in deep cuts. The subgrade thus softened is not able to support the track, and the heavy loads to which it is subjected, with the result that track and ballast are pushed down, displacing the underlying earth which heaves up in the cut ditches. When this happens the track is brought up to its former level on ballast and eventually the track forces remove the earth which has been displaced and clean out the cut ditches. This repeated from year to year, however, results finally in the track being underlaid for a depth of several feet with a material much more porous than the adjacent earth, into which the water pours without any means of escape.

---

*Paper before 1916 annual convention of Kansas Engineering Society.

In fills this same condition is caused in several ways. Frequently there is insufficient allowance made for the shrinkage of embankments and the track thus settling below the established grade is raised on cinders or ballast. Also in a great many instances the original embankments were not built with slopes flat enough to prevent slides when the filling material became more or less saturated under heavy rains. These slides in many cases extended to or under the track and were temporarily repaired by dumping in cinders or ballast to the extent of making the track passable. Again this condition is brought about by the continual raising of the track on ballast as it is surfaced from time to time.

In all of these cases the shoulders of the embankment are usually brought up with earth secured at a time and in a manner most convenient to the track forces. The result, however, is the same as in the cut in that the track becomes underlaid with a stratum of porous material enclosed within more or less impervious earth.

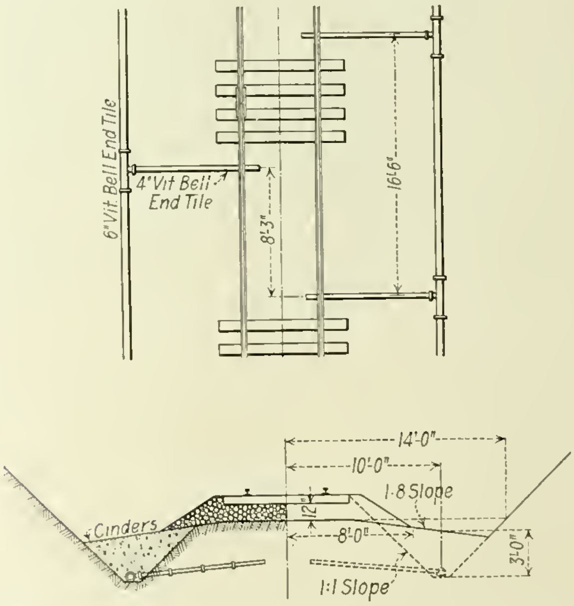
The result of this condition is to make it almost impossible to maintain track in proper line and surface even with a large continual expenditure of money for track labor and also in the case of embankments to cause continual slides. These slides are due to the water, which collects in these porous pockets, seeping out through the fill, thus saturating a plane extending from the bottom of the pocket to the outer face of the embankment, upon which the superimposed material easily slips.

To alleviate or remedy in cuts the conditions referred to, the Atchison, Topeka & Santa Fe Railway, during the past year, has been using on its Eastern District a system of tile drains which may be briefly described as follows: The side of the cut is produced down to a point about 3½ ft. below subgrade to form one side of a ditch in which is laid the main tile. The other side of the ditch is formed by a plane extending from the upper side of the end of the track tie, with an approximate slope of one in one, until it intersects the plane 3½ ft. below subgrade. Using the Santa Fe standard roadbed this results in a ditch about 3 ft. deep, 1 ft. wide at the bottom and 7 ft. wide at the top. In this ditch is placed the main tile which usually is 6 in. vitrified, bell end. Connected to the main by means of tees are 4 in. laterals spaced 16½ ft. apart and extending usually to a point between the rail and the center of the track. These laterals are laid so as to tap the bottom of the ballast or cinder pocket. In most instances a line is laid on each side of the track and the laterals are staggered so that one lateral occurs in every 8¼ ft. of distance. The lateral trench is usually backfilled with the same material with which the track is ballasted while the main ditch is filled with cinders the surface of which conform to the bottom of the original cut ditch. The ballast is then redressed to standard section and the job is complete.

For draining these pockets in embankments the Santa Fe has been using what are known as "French" or rock drains. These are simply trenches filled with broken stone. These trenches are usually from 3 to 4 ft. wide, ordinarily at right angles to the track and extend to a depth sufficient to drain the troublesome pocket. In some cases they extend entirely through and in other cases only from about the center to one face of the embankment depending upon size, location and character of the pocket to be drained. The distance they are spaced apart also depends upon these same conditions, and is determined by the engineer from an examination on the ground. The bottom of the trench is made with sufficient grade to insure the flow of water from the pocket to the face of the embankment. This grade should be made great enough so that slight future settlement of the embankment will not destroy its effectiveness. The rock used for filling the trench is usually "one man size rip rap." In some of the drains which have been built, rock of this size has been carried up to within 1 ft. of the top of the trench and the remainder filled with crushed rock of the size used for ballast. This was done on the theory that the finer rock on top would prevent dirt from sifting in and gradually filling the interstices in the larger sized rock, which, should it occur, would tend to lessen the effectiveness of the drain.

There have been several places where conditions were such as to afford very poor means for carrying water away from the foot of the embankment in which these drains have been installed and in such cases a longitudinal drain has been constructed at the foot of the slope into which the cross drains connect. This longitudinal drain is similar in construction to the cross drains and carries the collected drainage into the nearest ravine or depression of sufficient depth to carry the water away from the roadbed.

In places where the fill is light and the pocket or stratum to be drained is not deep, a condition which usually is due to the repeated raising of the track due to surfacing from season to season and the consequent raising of the shoulder with earth to permit of standard ballast dressing, the drains installed are ordinarily smaller than these mentioned above, being generally about 2 ft. wide and filled with spalls or rock smaller than one-man size rip rap. In other places where fills are very heavy, or where side hill construction is encountered, and the drainage conditions are so bad as to make it impossible to keep the road in operation on account of slides, these drains, particularly those used as longitudinals have been made much larger than any of those above described and serve the purpose of wall for bracing or retaining the roadbed as well as a drain.



Sketch Illustrating Method of Draining Wet Cuts with Drain Tile on the Eastern Lines of the Atchison, Topeka & Santa Fe Railway.

It has frequently been found necessary to flatten the slopes of embankments as well as to install these drains entirely to prevent the occurrence of slides. Very often the nature of the earth is such that it will not stand on a 1½ to 1 slope as is usual in the construction of embankments and in such cases the installation of drains will not entirely prevent slides. On the other hand very flat slopes show a tendency to slide where porous pockets exist under the track and, therefore, in such cases a combination of flat slope with rock drains should be used.

The performance of these systems of drainage has been very satisfactory. The amount of water drained from roadbed by them for long periods of time, after rainfall has ceased, is surprising. The cost of these systems is greater than those ordinarily used but it is justified by the better and safer track obtained and the decreased cost of maintenance.

The accompanying drawing illustrates the method of draining wet cuts with drain tile, as practiced on the Santa Fe Eastern Lines.

Engineering and Contracting

Devoted to the Economics of Civil Engineering Design
and to Methods and Cost of Construction

EDITORS
H. P. Gillette C. S. Hill C. T. Murray S. C. Hadden C. W. Malcolm

Volume XLV. CHICAGO, ILL., FEBRUARY 23, 1916. Number 8.

THE CONCRETE ROAD BUILDING CONFERENCE.

The closing declaration of opinion of the concrete road conference held last week in Chicago scintillates conservatism. There is not a thought suggested that can alarm the most timid adherent to the traditions. This is not criticism. Little else could have been expected and, in fact, nothing else would have been proper. Some of the committees showed a more venturesome spirit but obviously in a declaration of opinion of the conference as a whole nothing could be shown of even their mild radicalism. So we had, as has been said, a pronouncement of accepted practice and no incursions into bordering fields of possibilities.

One of these possibilities is the more scientific proportioning of materials. Two of the committees, that on aggregates and that on proportions and consistency, ventured into the field rather timidly, but they ventured and that was a very creditable and useful act in itself. It will aid in bringing reform, and reform is needed unless the road engineer is content to wait until forced ahead by the strides being made toward scientific proportioning instead of assuming leadership in the advance.

In the declaration of opinion proportioning based on sieve analysis or by relative density tests is considered not practical. The committee on proportions "appreciates the practical objections," but believes that these objections could "probably be eliminated." To anyone who doubts this "probability" we suggest perusal of the discussion by Major W. W. Crosby in our issue of Jan. 12, 1916. Or, better, consider the practical example described in our issue of Feb. 9, 1916, of furnishing sieve analyzed aggregate for the Winnipeg aqueduct work. These articles are not mentioned as being unique, but simply for being among the latest. Proportioning concrete by sieve analysis is not merely an ideal of the laboratory; it is a practical possibility in the field.

RIVER AND HARBOR IMPROVEMENT APPROPRIATIONS AND ENGINEERS AND CONTRACTORS.

The smallest river and harbor appropriation bill reported from committee in a number of years has just been laid before Congress. The bill carries in round numbers $43,000,000, and even this sum will not be allowed to stand without an active contest. Led by Congressman Frear in the House and by equally energetic leaders in the Senate, a vigorous and determined attempt will be made to cut drastically all appropriations and to eliminate entirely appropriations for many projects. Last year this same opposition reduced a larger initial amount to $20,000,000. A similar reduction this year may reasonably be anticipated.

By engineers, and particularly by contractors, reductions in river and harbor improvement expenditures are regarded with disappointment. Indeed, among contractors, at least, the word disapproval better expresses the feeling possessed. These attitudes are entirely natural. Are they clearly wise? There is much reason for thinking that they are not. River and harbor appropriations have been very largely misdirected when not absolutely wasteful. Every engineer and contractor knows the truth of this statement. He also knows, if he has considered the subject at all, the causes which lie behind such waste and misdirection of funds. Regarding these causes with every degree of charity possible, it is not good citizenship to uphold them. But there is another reason, and from a purely selfish point of view a very cogent reason, why they should not be upheld.

The fight against log-rolling and pork-barrel methods of public expenditure for river and harbor improvements is not confined to a group of politicians in Congress. Many influential newspapers have taken the side of the opposition to pork-barrel methods. The number of these newspapers has increased within a year. Public sentiment demanding a change of methods is growing. In time, and perhaps very soon, this sentiment will develop into a positive and more than likely into a demagogic opposition. Then we shall have a swing of the pendulum of popular feeling too far in the direction of economy. Parsimony in river and harbor improvements will result and such a result certainly is not to be desired. Wise expenditure for improving navigation routes is legitimate and necessary. Expenditures as great as the sum named above are not too great if the appropriations are wisely allotted. Any sum, however small, is, however, far too great if it is wasted on insignificant streams and ports to curry political favor or repay political debts.

In view of these facts, it is the part of selfish wisdom for contractors and engineers not to oppose, but rather to support, all endeavors to place our river and harbor appropriations on a basis of sound engineering economics. In the end more work for the contractor and engineer will result.

AN OPPORTUNITY TO SERVE THE PUBLIC AND OURSELVES AT THE SAME TIME.

It has occurred to the editor that publishers of technical journals, consulting engineers and water works supply men have a grand opportunity to serve the public while indulging themselves in a little enlightened selfishness. Such an attractive possibility is clearly worthy of discussion.

It is entirely apparent to everyone that in these days the superintendent of water works must possess considerable knowledge of the water works business in all its branches if he is to fill the position acceptably from the service, economic and public health standpoints. It is equally apparent that the average superintendent, particularly in cities under 15,000 population, is not so equipped. Moreover, if he is a conscientious man and begins a close study of the business as soon as he assumes office, his studies will all too soon be cut short by the ruthless hand of party politics. All this and much more of like import is only too well known. What are we going to do about it?

There is an unmistakable trend toward putting competent men in this office. This we admit, cheerfully enough, but the progress being made is not rapid. It is with the hope that the movement in this direction can be somewhat accelerated that we discuss the community of interest in this subject.

The publishers of a journal like Engineering and Contracting never even come close to finishing their labor on water works subscription lists. Water itself is scarcely more fluid than a list of water works subscribers The publisher must follow the rise and fall of the individual operator and this is, believe us, a very bothersome and expensive undertaking. Published lists are soon out of date, and require constant revision to keep them fairly accurate. The publishers would be saved much expense and worry if water works operators only stayed put a reasonable length of time.

Consulting engineers find it hard to build up an acquaintance among water superintendents. Work of sufficient importance to warrant the calling in of an expert does not arise often in connection with any water plant. Between two such jobs the management usually undergoes several changes and the engineer on the first job does not have the call on the second job that acquaintance would give him. True, he has the aid of the prestige gained by his first engagement, but this is outweighed very frequently by the lower price asked by another engineer when the second project is taken up. In the long run all consulting engineers suffer from this fee-cutting process.

When we come to consider water works supply men we must be greatly impressed by what it costs them to keep up with the procession. Very recently we heard a salesman express surprise that a certain standard machine, which has been on the market and energetically pushed for 20 years, was brand new to a water superintendent upon whom he had just called. We reminded him of the fact that this superintendent was new in the business. Thus the selling cost to supply men is enormously increased by the constant necessity of calling upon and circularizing the newcomers in the field. Very often a superintendent is about ready to place an order when his career in the water works business is cut short in the manner hereinbefore mentioned. Then his successor must be educated up to the same point. Eventually the sale of goods, long needed, is made.

In theory the general public pays all these additional costs, but as it works out in practice some of the loss must be made up by the three classes of men here mentioned. Their profits are oftentimes infinitesimal in the strict mathematical sense that they approach zero as their limit.

In view of the truth of all the foregoing statements we suggest that the larger water works associations appoint committees to prepare publicity matter setting forth the advantages to the public of having competent water works men in office at all times. We have no doubt that the publishers, consulting engineers, and such supply men as are eligible to membership, would gladly and energetically serve on such a committee. That the labors of this committee would result in putting and keeping good men in the office of water superintendent we do not doubt.

Briefly this is our suggestion as to how the interested parties can be selfish and altruistic at the same time. Further diagraming of the suggestion is unnecessary.

CONCERNING OUR KNOWLEDGE OF CONCRETE AND ITS PROBLEMS.

Although rapid strides have been made in the past few years in concrete design and construction, we have hardly advanced beyond the embryonic stage in their development. Designers and builders are still feeling their way and generally are working out their own peculiar problems as these problems present themselves. Engineering literature contains much which will serve as a guide to the designer and builder, but one should not trust implicity recorded information without a thorough knowledge of the conditions governing the constructions described. The young designer especially is apt to accept too readily the recorded work of those who have preceded him, when in reality he should preserve an open mind during his investigations.

As is necessarily true of any industry which has developed as rapidly as has the concrete industry, the builder has not been able to delay construction until the designer had accumulated adequate scientific knowledge, in fact we would not now have reached the present state of development had this program been adopted. There are so many uncertainties entering into the problem of securing a high-grade concrete in place that rapid progress could only be attained by experimentation, much of which had to be done by the contractor, or by commercial interests, or at least by those not connected with any of our testing stations.

We believe that the most important lesson taught those who attended the recent convention of the American Concrete Institute and the National Conference on Concrete Road Building was that of humility. If anyone came to these meetings with the idea that his knowledge of concrete was satisfactory he must indeed have possessed hopeless egotism if such an idea was not knocked out of him. Few of the real problems of the concrete industry are settled; yet we can claim satisfactory progress when all the difficulties confronting the investigator are considered. The meetings held in Chicago last week served their main purpose, as they certainly impressed upon those interested in concrete the need for close and continued study of the problems of concrete design and construction.

TWO UNPOPULAR CONVERSATIONAL TOPICS.

The editor has recently attended the annual conventions of four state organizations of engineers. The study of the engineer, be it known, is no less a part of the business of the engineering journal editor than is the study of engineering. Therefore the editor frequently sallies forth to find out what engineers and contractors are thinking and talking about. Usually he listens—occasionally he asks questions.

A year ago there was much war talk at these same conventions. There was also much talk about hard times and much lamentation over the evil days which had come upon us—particularly in the construction field. Everyone felt depressed and made no successful effort to conceal the fact.

This year a complete change was everywhere apparent. Not only did the men attending the conventions refrain from bringing up such subjects as war, politics and hard times, but they turned a deaf ear to anyone who attempted to obtain their views on these subjects. Their talk was wholly of their business plans for the year. In reply to specific questions they asserted that they expect to have a busy year—that the outlook is positively very good.

To our mind the fact that engineers and contractors are talking business and not war or politics is a fact of the highest significance to all engineering and allied interests.

NEW EVIDENCES OF CO-OPERATION BETWEEN LABOR AND CAPITAL.

The numerous and costly strikes and lock-outs which have occurred during the past few years at last seem to have impressed both labor and capital interests that such methods of attempting to gain advantages are generally harmful to all concerned—capital, labor and the public. For a time labor unions appeared to have the advantage, in that they were more closely organized, but at the present time capital interests are probably no less closely organized. That both interests are being brought to a realization that co-operation is advisable now appears evident. In the past both capital and labor have sought by means of legislation to gain advantages and undoubtedly will continue to do so for some time to come. In seeking such legislation each side has endeavored to preserve secrecy, which has resulted in the maintenance of representatives at many state capitols. In general, legislative measures have failed in their purpose, with the possible exception of such laws as pertain directly to the safety and welfare of employes.

For the first time in the history of any state an agreement has been effected by representatives of capital and delegates of labor under which no bills affecting wages and employment conditions are to be introduced in the New York State Legislature without previously being submitted to a conference of representatives of both sides. Such an agreement will undoubtedly do much toward preventing the enactment of laws which are clearly favorable to a single interest, and the New York experiment will undoubtedly be watched with great interest by men in other states.

Another point on which labor and capital seem to be approaching common ground concerns the physical examination of employes. This topic was the one which attracted chief attention at the recent Industrial Safety Exposition conducted by the Industrial Commission of Ohio. Both employers and employes took part in the discussion, and such interest was shown that a considerable part of the regular program covering other topics was crowded out. The numerous workmen compensation laws passed in various states have created on the part of the employer a demand that employes prove their physical fitness at the time of employment by a rigid examination. After much discussion the entire subject was referred to a committee which is to meet in Columbus in April to hold conferences with representatives of both labor and capital. An attempt will then be made to agree upon a physical examination bill to be introduced at the next session of the Ohio Legislature.

In addition to the above examples there are numerous other indications that we are rapidly approaching a more satisfactory solution of the labor problem. A disturbing factor, however, has arisen in connection with the recent sharp advances in wages granted by employers engaged principally in filling war orders. This is bound to require clear thinking on the part of both labor and capital representatives if serious future trouble is to be avoided.

EDITORIAL COMMENTS.

Road constructions that carried successfully horse haulage broke down under the automobile and stronger constructions were devised. Many fingers are pointing to the motor-truck-proof road as a necessity of the immediate future. It is a timely thought. But a road is no stronger than its bridges. The state of New York, with 7,000 plus miles of motor-truck-proof highways, has on those highways some 23,000 bridges unsafe for a five-ton truck load. The activities that are promoting road construction for motor trucks must not forget that motor-truck-proof bridges are vital parts of such construction.

Considering the improved road as a factor in military operations, how heavy loads will bridges normally be called upon to bear? Artillery loads are heavy, concentrated loads, but presuming modern field pieces to be handled in their normal units, few of these units, according to Major Amos A. Fries, who recently spoke before the concrete road conference on permanent roads as a factor in national defense, will exceed the concentration of a 16-ton road roller. Here, then, we have a standard, with which the road builder is perfectly familiar, for measuring bridge strength for military operations.

In a certain state engineering society, the best in the county in our opinion, there is a movement on foot to curtail the powers of the secretary. It is suggested that a committee be named to handle some of the matters now handled by the secretary. This would be a backward step. The whole tendency in government today is to concentrate responsibility rather than to distribute it. This society is the best of its kind because it has a thoroughly efficient secretary, with broad powers, who thinks and plans for its success throughout the entire year. Such interest could not be sustained by any set of scattered committeemen. While engineers are arguing for the commission-manager form of government it is a bit incongruous to move the abandonment of the same principle in the government of their professional bodies.

Just as we had reached the conclusion that the last word had been said in discussing the influence of the motor vehicle on the building of hard roads, along came the engineer of an Illinois town with a new variant of the subject. He says that the farmers living within five miles of a village will have their interest in good roads quickened if the village buys a motor chemical fire engine and holds it in readiness to speed to a burning farm-building in response to a telephone call.

FOUR EXAMPLES OF CONCRETING GANG ORGANIZATION FOR ROAD WORK.*

Example 1: Pennsylvania, Easton—Bethlehem Model Road:—The best results were obtained with a gang organization as follows:

Gang.	Cost per day.
1 foreman at $3	$ 3.00
1 mixer operator at $3	3.00
1 fireman at $2.50	2.50
2 templet men at $2	4.00
3 men spreading at $2	6.00
2 men floating at $2	4.00
1 man finishing at $2	2.00
2 men on forms at $2	4.00
1 man changing chute at $2	2.00
2 men handling cement at $1.75	3.50
7 men on wheelbarrows at $1.75	12.25
7 men shoveling at $1.75	12.25
1 utility man at $1.75	1.75
1 waterboy at $1.50	1.50
32 men in total gang	$61.75

This list schedules the men according to their special duties. The first task in each day's work was from the previous day's work to bring forward the forms and other working appliances and to cover the previous day's concrete with earth. All men, such as templet men, floaters and finishers, were employed in this task. The three men handling concrete also placed the expanded metal reinforcement and the expansion joints. Laying a slab 7 in. thick and holding the material in the drum for a 90 sec. mix, this gang averaged 525 sq. yd. per day at a cost of approximately 11.7 ct. per square yard. A No. 16 Koehring paving mixer, with boom and bucket delivery, was used. With a shorter mixing time, say 45 sec., it is suggested that the gang be increased three to five men on wheelbarrows; with such an increase it is estimated that the yardage could be increased 50 per cent. Data reported by William D. Uhler, Chief Engineer, State Highway Department.

Example II: Illinois State Aid Road Work Practice.—The data given are based on experience on 25 to 30 jobs of state aid road work representing approximately 500,000 sq. yd. of pavement. Assuming excavation complete and all material delivered on the work and that the subgrade is in average condition, the following crew is considered to be most efficient under average conditions on work similar to state aid road work in Illinois.

General—	Number.
Superintendent	1
Foreman	1
Front End of Mixer—	
Wheeling sand	2
Wheeling stone	4
Extra shovelers	2
Handling cement	2
Bundling cement sacks	1
Trimming subgrade	1 or 2
Rear End of Mixer—	
Shovelers	3 or 4
Finisher	1
Curing conerete	2
On Mixer—	
Engineer	1
Fireman	1
Forms—	
Setters	2
Water—	
Pumpman	1
Miscellaneous—	
Watchman	1
Waterboy	1
Total	27 or 29

The list given needs some explanation to be entirely plain. First the assignment of only one or two men to trimming subgrade assumes that the subgrade is already practically correct. Of the three or four shovelers at the rear end of the mixer, two also handle the strike-board and one also occasionally assists the finisher. At times of any delay in mixing operations, practically the entire gang is turned to covering the concrete with earth. Under ordinary conditions, however, it is necessary to assign two men to covering and sprinkling concrete in addition to the work done by the whole gang. The gang is for a two-bag batch mixer, and with this machine its average daily output of 18 ft. wide and 7 in. thick pavement is about 800 sq. yd., working day 9 hr., mixing time per batch, 35 sec. The average cost of mixing and placing concrete and of setting forms and joints is 10 ct. to 12 ct. per square yard. A single day's cost may run as low as 8 ct. per square yard, but an average job of any size, figuring repairs, fuel and depreciation on mixer, brings the cost between 10 and 12 ct. where labor receives from 20 to 25 ct. per hour. A smaller gang will reduce the unit cost slightly if no account is taken of interest, overhead, etc. The slower progress, however, runs up these fixed charges so that in the end, the cost is greater rather than less. Data reported by H. B. Bushnell, Division Engineer, State Highway Department.

---

*Collected by special committees of the National Conference on Concrete Road Building.

Example III: Wisconsin, Milwaukee. County Roads.—An efficient gang organization for conditions prevailing in Milwaukee County has been found to be about as follows:

Gang.	Cost per day
1 foreman at $5	$ 5.00
1 timekeeper at $5	5.00
1 engineer at $5	5.00
1 fireman at $2.50	2.50
1 pumpman at $2.50	2.50
1 form setter at $2.50	2.50
1 finisher at $3	3.00
2 strikeoff men at $2.50	5.00
2 puddlers at $2.50	5.00
2 cement handlers at $2.50	5.00
1 boy bundling sacks at $1.50	1.50
1 waterboy at $1	1.00
6 sand laborers at $2	12.00
12 stone laborers at $2	24.00
1 man removing forms at $2	2.00
2 men covering concrete at $2	4.00
1 man sprinkling at $2	2.00
1 man trimming subgrade at $2	2.00
38 men total	$89.00

The particular road on which this gang worked contained 17,280 sq. yd., was 18 ft. wide and averaged 7 in. in thickness. The subgrade was clay and required little sprinkling before laying the concrete. Wheelbarrows were wheeled directly on the subgrade without planks. Sand and gravel were placed in the middle of the road and cement on the side. Water was available at the job and was pumped through 2 in. pipe by a steam pump. A 16-ft. paver was used with an open spout for distributing the mixed material. The mix was 1:2:3½, two bags of cement being used to a batch, and 11 cu. ft. of aggregate. Protected joints were placed every 50 ft.

The actual number of days consumed in the construction of this particular piece of work was 33, of which five were Sundays. Of the remaining working days, two were lost because of rain and a defective pump. This left 26 days for actual construction work. During this period, the maximum output for one day was 1,000 sq. yd. and the minimum 264 sq. yd. The average output was 665 sq. yd. per day or 332½ lin. ft. per day. The actual labor cost for mixing and placing was $0.1396 per square yard, which included labor incurred in supplying water covering and sprinkling concrete and also a watchman during the construction period. The cost to the contractor for lost time, moving plant to and from the job, the laying of pipe, etc., amounted to $0.0201, giving a total cost per square yard for labor of $0.1597. The timekeeper looked after the ordering of materials, spotting of cars and unloading and placing of materials on the job. A cheaper engineer might have been employed but it is believed that the results obtained justified the additional expense. The man employed in trimming the subgrade saved more than enough in materials to pay for his wages. Data reported by F. W. Whitlow, Superintendent of Construction, County Highway Commission, Milwaukee County, Wisconsin.

Example IV: California Highway Commission.—(1) Specific crew organization employed on recent jobs.

DIVISION III—MAINTENANCE REQUISITION, 155, AUBURN BOULEVARD.

Concrete Crew:	
1 mixer engineer at $4.00	$ 4.00
1 foreman at $4.00	4.00
1 water boy at $2.00	2.00
1 cement man at $2.75	2.75
2 finishers at $3.00	6.00
2 men on tamp. at $2.75	5.50
4 spreaders at $2.75	11.00
15 laborers at $2.50	37.50
Total	$72.75

Average for 20 good days' run = 118.9 cu. yd. per day.

$$\frac{\$72.75}{118.9} = \$0.613 \text{ cu. yd.}$$

Note.—Mixer rent of $10 not included in above.

DIVISION III—STANISLAUS COUNTY, ROUTE 13, SECTION A.

Concrete Crew:	
1 mixer engineer	$ 3.63
1 foreman	4.50
1 finisher	3.00
6 spread tampers at $2.75	16.50
13 shovelers and wheelbarrow men at $2.50	32.50
Total	$60.13

16 days' average run = 101.4 cu. yd.

$$\frac{\$60.13}{101.4} = \$0.592 \text{ cu. yd.}$$

(2) Conditions and amount of work, plant used and other reasons influencing choice of organization employed.

See (3) for conditions and amount of work. No special conditions influenced the choice of organization. The organization (see 1 above) is customary where a two-bag mixer is used, and an output of from 100 to 150 cu. yd. per day is expected. The following crew can probably be considered as typical of work throughout the state:

1 foreman	$ 4.00
1 mixer engineer	4.00
1 cement man	2.75
1 finisher	3.00
2 tampers and strike off men at $2.75	5.50
6 men spreading, shoveling up loose materials, checking up subgrade, etc., at $2.75	16.50
13 men on wheelbarrows and shovels at $2.50	32.50
25 men. Total	$68.25

This crew could easily turn out an average of 125 cu. yd. of concrete per day at a cost of $0.54 per cubic yard. Delays due to shortage of material, supplies, water and mixer trouble generally tend to keep the average from 10 to 20 ct. per cubic yard higher. The figures given above are for average conditions, and for the average run of labor. There have been times when contractors with an especially capable and experienced crew of men and no other difficulties have been able to mix and place concrete for as low as 40 ct. per cubic yard, and even lower, and on force account work (work done by the State under day labor) we have done the work for as low as 48 ct. per cubic yard on a single day's run. But out of over twenty contracts under way in Division III this summer not one mixed and placed concrete as low as 50 ct. per cubic yard, and the average was much higher.

The Auburn Boulevard job consisted of laying a concrete base 4 in. thick, for the most part, on an old oil macadam base. The old pavement was first scarified and the top 2 in., which consisted of a mushy mixture of oil, dirt and a small amount of rock, was removed. The remaining base, on account of the amount of rock and oil contained, was rather difficult to prepare accurately for a 4-in. base. On this account the header and subgrade charge is higher than is customary on work of this nature.

(3) Records of output or costs indicating efficiency of crew organization as employed.

M. R. No. 155—Auburn Boulevard.

1. Length of concrete pavement, 18,273 lin. ft. = 3.46 mi.
   (Part 18 ft. x 4.5 in.; part 15 ft. x 4 in.)
2. Total yardage, 3,963.5 cu. yd.

		Per cu. yd.
3. Labor cost of mixing and placing (not including water supply or curing or repairs)	$2,994.73	= $0.730
4. Cost of curing concrete	837.23	0.211
5. Cost of running pump and water supply	310.09	0.076
6. Cost of laying and removing water pipe	95.43	0.024
7. Cost of headers	1,277.89	0.322
8. Cost of shaping subgrade	1,073.50	0.270
9. Cost of unloading and hauling rock, sand and cement	4,480.35	1.130
Total cost		$2.763

10. Average haul = 0.7 miles.
    Items 3 to 9 = $11,069.22, or $3,200.00 per mile.

The mixer used on the Auburn Boulevard was old and as the work progressed the break-downs were numerous, causing disorganization of crew and consequent increased costs. Delays due to shortage of materials toward the latter end of the work added unfairly to the cost of the concrete. The total cost of $2.76 per cubic yard of concrete in place is not excessive, but is higher than should be on a large job and where there are no serious difficulties to be overcome.

(6) Discussion of specific or general questions of crew organization that experience indicates needs enlightenment or investigation.

No suggestions can be made along this line, as there are no particular crew organization problems connected with concrete paving work. The only real problem is the problem of the superintendent always to organize the layout of his work so as to prevent serious delays in any one part of the organization. Thus, he must plan his grading crew to keep ahead of the subgrade crew, the finishers must keep ahead of the hauling of materials, and the material men must keep ahead of the concrete crew. If each outfit can see only one day's work laid out ahead, there is from 25 per cent to 50 per cent loss of efficiency. On the day labor work in Stanislaus County, Contract D-50, the work was so regulated at the start that each unit of the work was at least one-half mile (representing four or five days' work) ahead of the other units. Data reported by A. B. Fletcher, Highway Engineer, California Highway Commission.

Summary from Examples.

Using modern paving mixers, a concreting gang for road work will consist of from 30 to 40 men. These are round numbers. In instances fewer than 30 men will suffice and in more rare instances a greater number than 40 may be required. The exact number will depend upon the nature of many controlling conditions. Also the number of men allotted to the several duties required to be performed is, likewise determined by the nature of these conditions. As illustrating th vagaries of organization recorded in practice, Table I has been compiled from data readily at hand. Doubtless some of the wide variation exhibited is due to inequalities of organizing skill but with all reasonable allowance for this cause, there remains important differences caused entirely by differences in conditions controlling the concreting work.

TABLE I.—DISPOSITION OF MEN IN CONCRETING GANGS FOR CONCRETE ROAD WORK.

Job.	Genl.	Front.	Rear.	Mixer.	Forms.	Water.	Misc.
I	1	16	9	2	2	..	2
II	2	12	7	2	2	1	2
III	2	22	8	2	2	1	2
IV	2	13	6	2	2	1	2
V Base	1	15	4	2	..	..	..
V	(2)	(29)	(9)	(5)	(1)	..	(3)
V Top	1	14	5	3	1	..	3
VI	1	5	10	1	..	..	..
VII Base	1	9	5	1	..	..	..
VII	(2)	(13)	(11)	(3)	(2)	..	..
VII Top	1	4	6	2	2	..	.
VIII	1	10	11	3	2	..	..

Concreting is but one operation in the process of concrete road building. The economic target is the lowest cost for the whole process, and the concreting operation must so co-ordinate with other conponent operations that the mark is hit. It may often be, therefore, that the most efficient concreting gang organization is not the one that would mix and place most cheaply a cubic yard of concrete in finished road slab considering this one operation as the beginning and end of all effort. The law of coordination has influence in an even more minute way. Consider for the moment the concreting operation to be independent of all others. On the Pennsylvania road work described later, it is the requirement that the batch shall turn 90 sec. Under this requirement, the most efficient gang organization has been found to be that of column one in Table II. Could the mixing period be cut in half the most efficient gang organization would be that of column two in Table II. Again, considering the gang organization for Illinois road work as given in Example II. By reducing this gang by a few men it is stated that a smaller unit labor cost could be obtained but the slower progress would increase interest and overhead costs enough to exceed the saving.

TABLE II.—GANG ORGANIZATION AND OUTPUT AS INFLUENCED BY TIME OF MIXING.

Thus—	1	2
Mixing time, seconds	90	45
General labor	1	1
Men in front	16	21
Men in rear	9	9
Men on mixer	2	2
Men on forms	2	2
Miscellaneous	2	2
Total men	32	37
Output sq. yd. average	525	787

Gang organization is determined then, first by the controlling construction conditions and second by the work organization as a whole. These determining factors are seldom constant outside of a single job and are often variable on a single job. No general formula is possible for solving all problems of concreting gang organization. The organization of each gang is a separate problem and must be so solved.

MAKING BOTTOM FOR PILES BEFORE DRIVING.*

By F. Lester Simon.

It is quite common practice to deposit filling of some suitable material between and around the piles of a pier both to increase the resistance of the structure as a whole to lateral displacement and to increase the columnar strength of the piles themselves by decreasing their unsupported length, and also, but to a less extent, increasing their bearing power by additional skin friction. Care must be taken while depositing the fill to bring it up uniformly, so that the lateral pressure on the piles as units may be equal on all sides. A concentration of material at one point is capable of disastrous results, viz: springing the piles out from under the caps or bowing the piles, with a consequent eccentricity of load, or even shearing off the piles near the mud line. Nevertheless, the fill is usually heaped up along the axis of the pier, sloping both ways from the center line, giving the structure a "backbone," as it were. Sand, gravel, broken stone, or rip-rap is the usual fill material.

While this method has been employed successfully many times, yet it has the decided disadvantage of difficulty in controlling the distribution of the fill, resulting in one notable instance in the collapse of the structure. Why not, then, make the fill before starting the construction? The difficulty of controlling the distribution still obtains, but—and herein lies the great advantage of this method—strict uniformity of distribution is not essential and the entire hazard of the first method is obviated. There are no lateral pressures on the piles, indeterminate in amount and direction, as in the previous method, and no tendency toward a settlement of the piles with that of the fill. Secondly, there is the advantage of economy, due to the fact that shorter piles may very often be used because of the increased skin friction of the fill and compressed mud beneath it, giving equal or better test penetrations than in the first method, and due also to the relative ease of depositing the fill from scows previous to the erection of the pier.

The superiority of this second method was ably demonstrated in 1912 in the construction of a four-track open pier by Sanford & Brooks Co., contractors, of Baltimore. The pier is of the half-filled type, approximately 62 ft. wide by 830 ft. long. A number of test piles driven over the area of the pier revealed unusually severe bottom conditions—18 to 20 ft. of water and 45 to 60 ft. of mud overlying sand and clay—from which it was obvious that a large percentage of the piles would have to be in lengths of 85 to 95 ft., and most of them spliced. Fears were entertained, too, for the ability of a pier in such bottom and of such scant width to resist lateral thrusts, even though properly braced with batter piles. The safety of the assumed safe load per pile used in calculating the design was questioned.

It was suggested, therefore, that a bottom be "made" before driving the piles by dumping heavy material from bottom-dump scows over the area of the pier. The plan was approved and the bottom deposited. The material used was mixed sand and gravel, dredged from the river, weighing about 2,800 to 2,900 lb. per cubic yard. Approximately 30,000 cu. yd. were deposited, with very satisfactory results. The river mud appeared to absorb the fill; it was compressed rather than displaced, although there was a slight upheaval on both sides of the deposit and some shoaling of the water over the deposit. Piles generally 10 ft. shorter than originally contemplated were driven to satisfactory final penetrations. Not one spliced pile was used. The fill served the additional purpose of staying the piles at the mud line and stiffening the structure laterally. The cost of the artificial bottom was easily offset by the saving in piling done, not to mention the advantage of greater security.

---

*Paper in Journal, Engineers' Club of Baltimore.

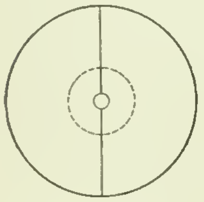
CONSTRUCTION WAYS, MEANS AND COSTS.

Weight of Stone Affected by Moisture.—Freshly quarried sandstones often weigh 10 per cent more than "seasoned stone" that has been exposed long enough to dry out. Crushed stone dries out rapidly. When crushed stone of a porous nature is bought by the ton it is wise to give consideration to this element of moisture content.

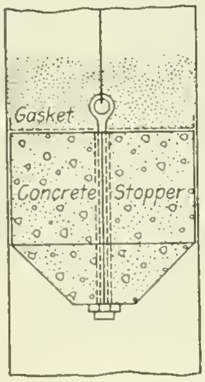
Shrinkage of Crushed Stone.—When hauled a short distance in wagons, crushed stone shrinks 5 to 14 per cent, the average shrinkage being about 8 or 9 per cent. Similarly when hauled in cars the jolting causes a settlement or shrinkage. Hence when purchasing stone by the cubic yard it should be specified that the measurement is to be made at the bins before hauling.

Precast Concrete Crossing Slabs.—Slabs of reinforced concrete, made in molds to fit spaces between the rails and held in place by clamps at the corners are solving the problem of making smooth railroad crossings for City Engineer T. F. McCauley of Cedar Rapids, Iowa, states the Iowa Highway Commission Service Bulletin. The slabs are used in pairs, each slab 24½ in. in width. With the proper expansion joints these exactly fill the space between the rails. They are reinforced with ½-in. rods spaced at 3 in. They are laid on the cross ties and being just the thickness of the steel rails vehicles pass over the crossing without a jar. Holes in the slabs permit the slab to be lifted out with a tripod for the purpose of replacing ties or rails or repairing electric connections or wires.

All-Concrete Stopper for Tremies.—In depositing subaqueous concrete by tremie use of wadding or a stopper is essential for the first filling of the tube. Various materials have been used for stoppers such as cement sacks, shavings, paper bags and sawdust. The material used is inserted in the tube at the top and filled above with concrete; as concrete is added the stopper descends the tube driving out the water until the tube is filled with concrete. Then the stopper escapes at the bottom and is buried as concreting proceeds. To avoid the objection of a buried foreign substance in the concrete an all-concrete stopper as illustrated is suggested by Mr. Harrison S. Taft. This stopper is a cylinder of cast concrete in two parts. It is lowered in the tube by cable and bolt as the concrete is filled in above. When bottom is reached the stopper passes out of the tube, the two halves fall apart and the released bolt and cable are drawn back through the concrete in the tube. The cast blocks are buried in the concrete mass but being of concrete they became a homogeneous part of the concrete fill.



Plan of Stopper



Section of Tremie Showing All-Concrete Stopper.

Loosening a Jammed Well Drill by Blasting.—The bit was jammed at a depth of 170 ft. A half cartridge of 60 per cent gelatine was inclosed in a small rubber sack and primed with a water-proof electric blasting cap. The charge was weighted and lowered, pulling the firing wire with it. When in position the charge was fired with a blasting machine, releasing the bit without much damage to the hole. Mr. M. C. Potter, who describes this method in the "Du Pont Magazine," says: "I have since found that it is sometimes necessary to make three or four such shots to release a bit. The cost of the work will average about $5, which is money well spent because of the time it saves the well drillers."

Cost of Operating and Maintaining Water Meters in Reading, Pa.—The cost of operating and maintaining the meter system was $4,161.72 for an average of 4,420 meters in service, or at the rate of $0.94 per meter per year, or 30 ct. less per meter than last year. The unit costs for the several subdivisions of operation and maintenance are as follows:

Abandoned as scrap	.099
Clerical service	.316
Repairs	.275
Reading	.183
Delivering meter bills	.067
Stationery and supplies	.007
Total	$0.941

Efficient Device Used in Grouting Lock Foundations.—The following data apply to the apparatus and methods used in grouting the seamy red Medina shale which underlies Locks 1, 2 and 3 of the new Welland Ship Canal:

After the loose material had been removed from the rock surface the drill holes were pumped out and their tops so trimmed that a tapered circular plug driven into them would form a tight joint. Several white pine plugs, 6 in. in diameter at the top, 2½ in. at the bottom, and 12 in. long, with a 1½- in. hole bored through the center, were provided. After driving a plug tight a 1½:1¼ reducer was screwed into the plug, from which a 1½-in. rubber hose led to a small diaphragm pump fitted with a pressure gage. A tub of cement grout, mixed in the proportions of 1 part cement to ⅓ part water, completed the equipment as first used.

The hole was then filled with grout, the joint at the top of the plug being left loose to permit the air in the hole to escape. The joint was then tightened and the pressure applied. If the pressure rose to 20 lb. and remained stationary without further pumping the material below was considered sufficiently tight. If the pressure did not rise, or if it rose and fell with the pumping, indicating that grout was entering some seam below, the pumping was continued until the pressure rose or the grout showed on the surface, necessitating the abandoning of the hole, temporarily at least.

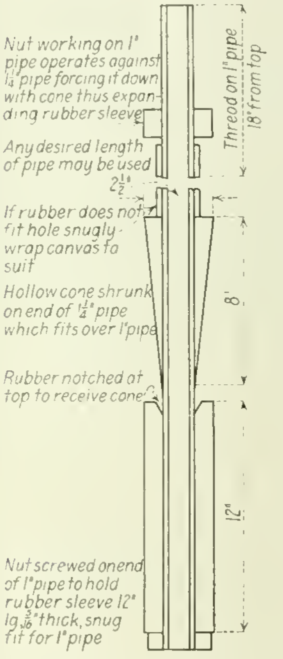

Nut working on 1" pipe operates against 1¼" pipe forcing it down with cone thus expanding rubber sleeve
Any desired length of pipe may be used
2½"
If rubber does not fit hole snugly - wrap canvas to suit
Hollow cone shrunk on end of 1¼" pipe which fits over 1" pipe
Rubber notched at top to receive cone
Nut screwed on end of 1" pipe to hold rubber sleeve 12" lg 3/16" thick, snug fit for 1" pipe
Thread on 1" pipe 18" from top
8"
12"

Fig. 1—Details of Plug Used in Hole for Grouting at Any Desired Depth.

Where grouting was required at a considerable depth the apparatus was modified as follows: A plug was made which could be lowered into the hole and which would plug it at any desired distance from the surface. The details of this plug are shown in Fig. 1. With this equipment the depth of the seam could be located. In some cases a seam as thick as 8 in. and only about 1½ ft. from the surface was encountered. In such cases it was considered better to cut shallow trenches through the surface on each side of the foundation than to attempt to inject sufficient grout to insure a perfect cut-off. The grouting below such a seam was done from the surface, before the trenches were cut, by dropping the plug just below the seam. The apparatus shown in Fig. 1 has proved so satisfactory that the wooden plug first used have generally been abandoned.—From article by Eric P. Muntz in The Canadian Engineer.

Sewage Siphon Troubles.—Bulletin 16, Engineering Extension Department, Iowa State College, says: The failure of sewage siphons to operate properly is usually due to one of two causes; either an air leak in the bell, or some part of the piping connected to the bell, or the clogging of the apparatus. As any air leaks usually show up shortly after the plant has been built, very few cases of trouble arise from that cause. On the other hand, many cases of trouble are caused by clogging. An accumulation of sludge around siphons is quite likely to cause clogging. For this reason such accumulations should be prevented and the siphons should be kept clean.

METHOD OF RELINING A TUNNEL WITH STEAM JETTED CONCRETE.*

By Harold P. Brown.

For many years a great deal of trouble has been caused to the engineers of the Chicago Great Western R. R. by the single track tunnel 2,600 ft. long at Winston, Ill. This is driven through gray shale which disintegrates into fine clay on exposure to air. The overlying strata were full of water and the tunnel has always been very wet. When first built it was timber lined, and in 1886 a portion collapsed, blocking traffic for many months. A brick lining was then placed inside the timber and the contractors were supposed to fill the space between the two. A 1½ per cent grade is encountered through the tunnel and the east bound freight traffic frequently required double headers.

A ventilating shaft was driven in the center of the tunnel when it was relined, but as this failed to relieve the smoke nuisance, a fan driven by a Diesel oil engine was placed at the west end to clear the smoke ahead of east bound trains. But the combination of smoke, water and the freezing during the winter due to the use of the fan, caused a serious disintegration of the brick, especially on the arch. Although analysis showed that the water was very pure, wherever the exhaust blast encountered the wet roof, the bricks laminated into strata about 1/16-in. thick, parallel with one face, sometimes the base, sometimes the side and sometimes the end. Between the layers was a black, gummy substance having an acid reaction. Nearly all the lower layer of the arch had fallen away, quite a portion of the second layer was cracked and a little of the third. Although a number of small weep holes were provided, they quickly filled up with fine clay and were ineffective, leaving the brick saturated with water which came down in streams, especially at the eastern end. Several thousand dollars were expended each winter in removing ice from the tunnel, and the relining was a serious problem. There was not sufficient clearance inside of the old lining to permit the placing of a new one strong enough to sustain the load. To take out the old lining and put a new one in its place while maintaining service through the tunnel was too dangerous to consider. The track levels at the portals and the treacherous character of the ground beneath the foundations prevented a lowering of the tunnel grade to accommodate a new roof lining during maintenance of service.

About a year ago the writer was called upon to examine the tunnel and suggest a method of relining which would meet the very difficult and unusual conditions. It was evident that the foundation was in satisfactory shape and that the side walls were but little injured. The roof, however, was in dangerous condition and required a lining which would take its proper share of the load.

My report advised a slight lowering of the track level; the drilling of a large number of weep holes 3 in. in diameter; the washing out of the clay between the upper brick and the old timber lining and filling the space with grout under pressure, and the removal of the cracked bricks. These should at once be replaced by an adhering layer of steam-jetted concrete, sufficiently reinforced, if necessary, to take its share of the load and continued 2 in. below the old surface.

In August, 1915, a work train, Fig. 1, was equipped for the job. The engine was provided with an extra air compressor, a steam pump and a dynamo for electric lighting. A pressure reducing valve set at 90 lb. was connected from an extra heavy nipple on the dome and a 2-in. steam connection carried with Franklin ball and socket joints and suitable couplings to a flat car on which was placed the concrete atomizer. The same car carried the cement, sand and gravel. As it would be difficult to control by hand a nozzle for jetting the concrete on to the roof, I designed for this purpose a nozzle car and trowelling machine which would place the concrete, would indicate the depth applied and would trowel or finish the final layer. The second flat car in the train carried this machine which was mounted on a platform capable of vertical or lateral adjustment, so that it count be made to swing from center line of arch. The nozzle was secured to a shaft mounted on suitable journals and was moved from side to side by a reversible two-cylinder steam engine. The same shaft carried the distance indicator and the trowelling devices. The nozzle car was mounted on wheels running on channel irons and could be moved back and forth 10 ft. by means of a stationary windlass. Steam connections to the engine and to the nozzle were made by means of suspended lengths of wire protected rubber hose. Beyond the second flat car was a box car provided with a railed platform on the roof. Here three men operated a water jet to clean the soot and dirt from the walls, and light pneumatic hammers for removing the defective brick. A signal whistle mounted on the engine which could be sounded from any part of the train was used to control the flow of air, water, steam and concrete. Two acetylene headlights as well as a number of incandescent lamps were used for general illumination.

When the work was started on Sept. 4, I found that the pneumatic drills provided were not heavy enough to penetrate the brickwork for the necessary 3-in. weep holes. Rather than delay until the proper drills could be obtained, I started operations at the eastern portal where water was pouring in streams through the roof. A mixture of 1 part cement, 3 parts of sand and 2 parts of pebbles was used with 10 per cent of water. These were mixed in the concrete atomizer at 90 lb. pressure, with the superheat obtained by dropping from engine working pressure through reducing valve. The concrete was carried through 2-in. hose and shot on to the brick by a steam jet. Although the pebbles at first dropped away, they neverthless forced the mortar into all the interstices of the brickwork and checked the flow of water. But very little material bounded off and this was collected and used.

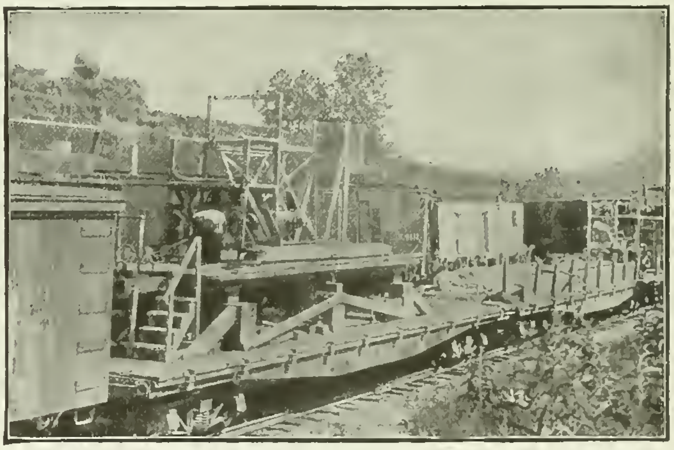


Fig. 1—Car-Mounted Plant for Lining Tunnel with Steam Jetted Concrete.

Before shooting a load, steam was jetted through the nozzle to complete the cleaning of the brickwork and heat it to the temperature of the concrete. In some places a layer of concrete 7 in. thick was jetted on to the roof and it set up so quickly that the work train could be immediately followed by an east bound freight without trouble from the engine exhaust.

In the final layer lime hydrate was added and the pebbles were omitted. The proportions were 1 part of hydrate to 10 parts of cement and 30 parts of sand. This gave a smooth flowing mixture and delayed the setting so that when the steam jet from the nozzle car was passed over the surface a second time without concrete, a smooth finish was obtained and trowelling was unnecessary.

The work was in charge of my superintendent while the men composing the crew were employes of the railway. Three men cleaned the roof, one man operated the nozzle car, one worked the windlass, one ran the atomizer and two men measured and loaded the materials. The improved machine is arranged so that but one man is needed to work the nozzle car and the windlass. It required about 5 minutes for the gang to clean 10 ft. of roof, load the atomizer, steam the roof and treat and apply the load. As it was important not to interfere with train service upon a double track road through a single track tunnel, only about 6 working hours per day were available in the tunnel. An average of 262 ft. of lining 12 ft. wide and 3 to 4 in. thick was applied in 6 hours, using 35 bags of cement. The concrete was found to be so strong that no reinforcement was needed, nor was it necessary to fill with grout the space above the arch. The work was finished in 41 days, and Mr. C. G. Delo, Chief Engineer, has pronounced it entirely satisfactory.

---

*Paper read at the February, 1916, meeting of the American Concrete Institute.

DESIGN, CONSTRUCTION AND UNIT COSTS OF SOOKE LAKE WATER SUPPLY WORKS, VICTORIA, B. C.*

By C. H. Rust, City Engineer and Water Commissioner, Victoria, British Columbia.

Victoria, the capital of the province of British Columbia, is situated at the south end of Vancouver Island, and has a population of about 50,000. The consumption of water in the summer is 80 and in winter 50 Imperial gallons per capita. All services are metered.

From 1872 to 1913 the city procured its water supply from Elk Lake, situated in a northeasterly direction, about five miles from the city. The writer has been informed that the first open sand filter beds constructed in North America were erected at Elk Lake.

Owing to the growth of the city, and to the capacity of Elk Lake being only about 2,500,000 gal. per 24 hours, the city was compelled to take steps towards procuring a more ample supply.

Negotiations were entered into toward purchasing the works of a private corporation known as The Esquimalt Water Works Co., who supply Victoria West and the District of Esquimalt, and who procure their water supply from the Goldstream Lakes, but the property owners voted against this proposition. These works have a maximum capacity of 13,000,000 Imp. gal. per 24 hours, and are situated about 17 miles north of the city.

In 1911 Mr. Wynn Meredith, western representative of Messrs. Sanderson & Porter of New York, was called in by the city to advise as to the best method to be undertaken to procure an adequate supply of water. Mr. Meredith undertook a very careful investigation of various projects, and it was finally decided to utilize Sooke Lake, which lies about 18 miles northwest of Victoria.

The lake is about 4 miles in length and its maximum width is half a mile. The area of the lake at 555 ft. above sea level is 978 acres. It was decided to construct a dam at the foot of the lake and raise the level 12 ft. This gives a total area of 1,180 acres. The watershed area is 31½ square miles.

In the scheme for the ultimate development, it is proposed to utilize the Leech River Watershed, which has an area of about 31 square miles. This watershed can be used by constructing a 5-mile conduit line to convey the water to Sooke Lake, and, if it should be necessary to do this, it is proposed to construct a dam at Sooke Lake to a height of 45 ft. It is estimated this will give a daily flow of 100 sec. ft., while the reservoir storage will be 17,358,000,000 Imp. gal. The scheme which has now been completed gives a reservoir capacity of 5,555,000,000 Imp. gal.

The contract called for the clearing of the land around the lake 15 ft. above low water; the construction of a dam at the foot of the lake, with necessary screen house, intakes, etc.; the construction of 27 miles of concrete pipe 40 in. in diameter (this involved the building of 27 miles of railway track, 2 ft. gage); the construction of 6 siphons and the necessary trestles, and temporary wooden trestles to carry the track; the construction of a telephone line; the building and clearing of a reservoir site, and the erection of a dam, screen house, valve chamber, Venturi meters, etc., at Humpback, which is about 12 miles from the city; and the building of 11 miles of 36-in. steel pipe, leading to the city reservoir. The contract was awarded to the Westholme Lumber Co. of Victoria. Following are some of their figures:

For earth excavation from 60 ct. to $1.50; for rock excavation from $1.75 to $7.50, the former being the price paid on the concrete pipe-line; the price for concrete for the dam at Sooke Lake was $11; for the dam at Humpback the price of concrete Class "C" was $9, Class "B" $10, and Class "A" $12.50 per cubic yard. The necessary clearing around the lake ranged from $150 to $250 per acre.

Bids were called for three classes of pipe for the flowline, namely, wood stave, riveted steel and reinforced concrete. The prices submitted were for the pipe laid and installed. Wood stave pipe was $2.47 per foot, riveted steel pipe $5.50 per foot, and reinforced concrete pipe $2.53 per foot, and it was finally decided to use concrete pipe.

On the pressure line, tenders were called for lap-welded, riveted steel, and lock-bar pipe. The prices quoted by the contractors were as follows: Lap-welded $7 per foot laid and connected; riveted steel plate 5/16-in. thick, $5.25; 3/8-in. thick, $6.25; lock-bar pipe, $6.80. It was decided to use riveted steel plates.

The contractors commenced operation early in 1912, but the progress made was not at all satisfactory, and in April, 1913, they abandoned their contract. The writer, as Water Commissioner, recommended to the Council that the work be proceeded with by day labor. This was approved and the city immediately put on a large force of men at various camps. The laborers were paid $2.75 per day for 8 hours, $1 a day being deducted for their maintenance. Free medical attendance was supplied by the city medical health officer.

The city completed the clearing of the land at Sooke Lake, carried out the construction of the dam, head works, etc., at the foot of the lake, and built the dam at Humpback.

It was considered advisable to call for tenders for the concrete flowline and the pressure pipe-line. The contract for the construction of the flow-line was awarded to the Pacific Lock Joint Co., and in place of a 40-in. pipe the contractors, having the necessary forms on hand, agreed to construct a 42-in. pipe for the same price, their tender being $2.29 per foot, including laying and installing but not including transportation.

The concrete pipe was made of a shell 3 in. thick and 4-ft. lengths, except the pipe used for siphons, which was more heavily reinforced and the shell was 4 in. thick.

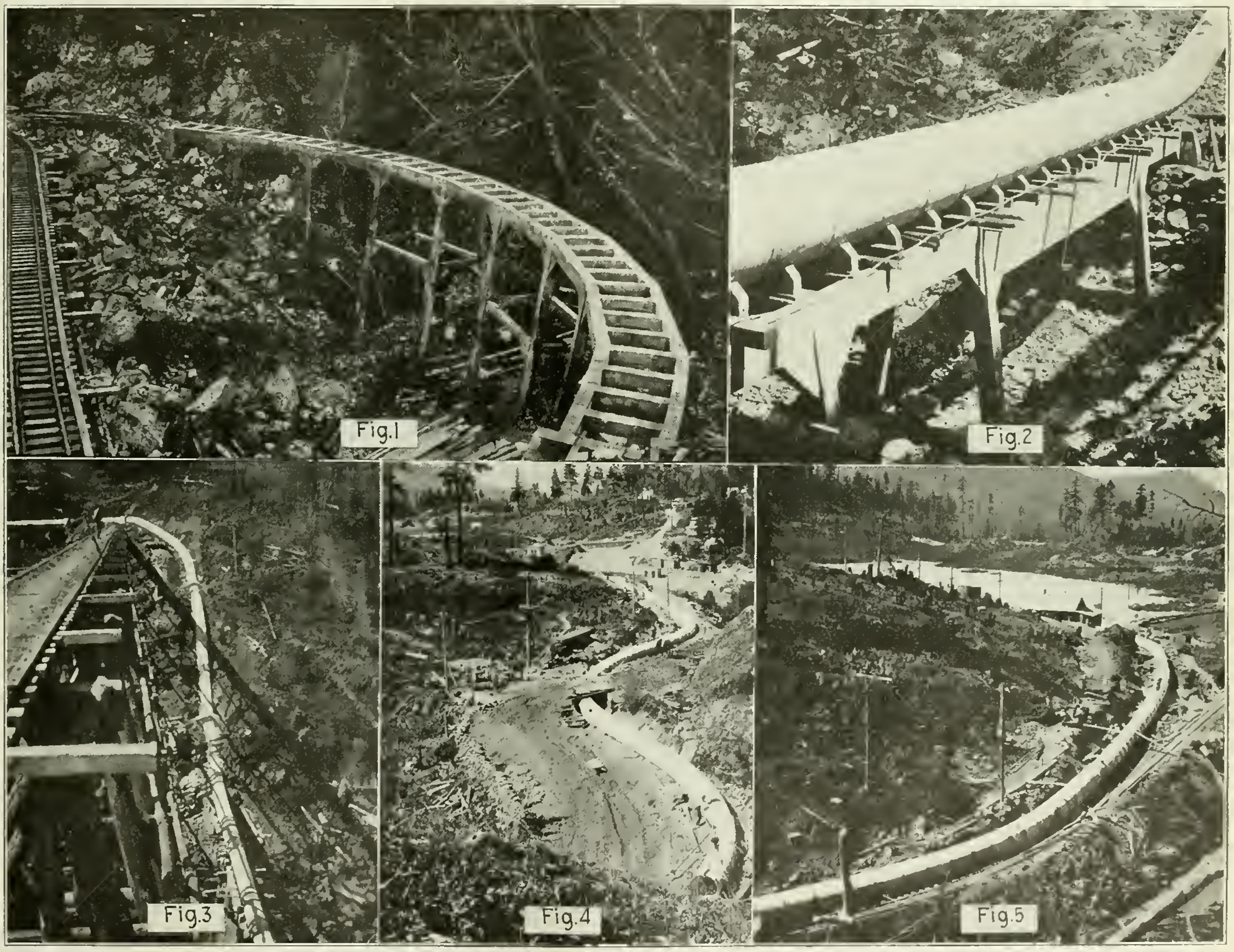
The city awarded the contract for the fabrication and laying of the riveted steel pipe to the Burrard Engineering Co. of Vancouver, for the following prices: 5/16-in., $5.50 per foot; 3/8-in., $6.25 per foot. The city carried out by day labor the necessary excavating and backfilling.

General Description of Works.—The following is a general description of the works as constructed: The dam at the intake channel at the lake is excavated 4 ft. below low water, where an intake tower is constructed, controlled by seven sluice gates. The openings of these gates are protected by screen cages. From the intake tower two lines of 40-in. riveted steel pipe are laid to convey the water to the screen house. Only one of these is in service at present. In the screen house is installed a set of 12 screens. The original screens had meshes of 40 and 60 openings to the inch, but these were found to be too small, and have since been replaced by 16 and 24 openings to the inch screens. Below these screens are the measuring weir and cascade steps. The screen house is constructed of concrete with a concrete roof. The dam is a composite structure, the west end being an earth embankment with a concrete core wall bonded into the natural rock. From the screen house to the east abutment an ogee weir section 200 ft. in length is built, which is generally about 15 ft. above the level of the natural rock.

---

*Paper before latest annual convention of the American Society of Municipal Improvements.

In the construction of the concrete flow-line a right of way 100 ft. wide was secured. All trees were cut down and any tall trees outside this area, which might in falling damage the pipe, were removed. The pipe is not covered except immediately in the vicinity of the Humpback reservoir, where it was thought slides might occur. At distances of 2,000 ft. apart on the conduit line there are open standpipes, and all inverted siphons, of which there are six, have waste outlets at the bottoms controlled by 6-in. gate valves. The deepest siphon is 600 ft. in length and has a maximum head of 90 ft. The whole of the pipe-line was constructed to a grade of 1 ft. in 1,000.



VIEWS OF THE NEW SOOKE LAKE WATER SUPPLY WORKS, VICTORIA, B. C.

Fig. 1—View of Concrete Trestle for Pipe Line. Fig. 2—Trestle No. 41 and Siphon No. 3. Fig. 3—One of the Siphons and Temporary Wooden Trestle Carrying Construction Railway. Fig. 4—View of Concrete Pipe Line Near Humpback. Fig. 5—View of Concrete Pipe Line at Humpback Reservoir.

One of the difficulties in connection with this scheme was to secure a reserve reservoir at a proper elevation and in fairly close proximity to the city. A suitable site was finally located at Goldstream on the Humpback road, about 11 miles from the city. This reservoir has a storage capacity of 136,000,000 gal. and covers an area of 33½ acres. This area was covered with a very thick forest. A portion of the reservoir site had black soil of a peaty nature. It was decided to cover this with a 6-in. layer of clean gravel. The dam is 560 ft. long, 60 ft. in height, and contains about 9,000 cu. yd. of masonry.

The water flows into the reservoir from the flow-line over a series of concrete steps. There is also constructed a by-pass 24 in. in diameter by which the water can be taken direct to the pressure line. There is in addition a submerged outlet controlled by a butterfly valve. During the past summer, owing to algae in the reservoir, the water has all been sent to the city direct through this by-pass. Owing to the great pressure, it was decided instead of delivering the water direct to the city to permit it to overflow into Smith's Hill reservoir, situated within the city and having a capacity of about 15,000,000 Imp. gal., which acts as a standpipe.

It is interesting to record that during the construction of this work, the greater portion of which was of a hazardous nature, no fatal accidents occurred.

The flow-line follows the shoulder of the mountain and the work involved the clearing of a dense forest composed almost entirely of Douglas fir.

The city, so as to protect the watershed from any possible danger of pollution, has purchased the whole area comprised within it, being about 15,000 acres, for the sum of $12 per acre. They expect ultimately, if they so desire, more than to compensate themselves for this expense by disposing of the very large amount of valuable timber which is on the watershed.

The abandoning of the work by the contractors, the Westholme Lumber Co., led to a protracted litigation. The company entered suit against the city, claiming $500,000 damages. The suit was heard in Victoria last winter and the judge hearing the case was assisted by two assessors who were civil engineers. The case lasted six weeks and a verdict was given for the city, but the company appealed and no doubt the case will be prolonged for some time before a final decision is reached.

The system was completed at the end of May and put into use on June 2, 1915.

Some interesting tests were made on the concrete flow-line. The original contract called for the delivery of 16,000,000 Imp. gal. per 24 hours through the 40-in. pipe. As previously mentioned the contractors without an additional cost constructed a 42-in. pipe and the maximum flow from tests through this pipe was 22,400,000 gal. in 24 hours.

One accident has occurred to the concrete pipe-line. During a forest fire a tree came down the side of the mountain and broke one pipe and cracked six more. These repairs, however, were quickly made.

The contractors for the flow-line guaranteed to maintain the pipe for a period of one year. At present there is a leakage in the 27 miles of about 500,000 gal. per 24 hours. It is expected that these leaks will be entirely eliminated when the necessary repairs are made.

Cost Data.—The following is the actual cost of the work carried out by the city:

Sooke Lake:—

	Per cu. yd.
Earth excavation in construction of dam at Sooke Lake....	$ 1.42
Rock excavation	4.24
Concrete in foundation of dam............	15.68

All the cement had to be shipped by rail and hauled by teams about ten miles over very rough roads. The gravel and cement were procured from the upper end of the lake, and had to be towed to the foot of the lake. This involved the placing of a tug in the lake, which had to be transported from Victoria over the mountain, and the construction of scows.

Concrete Pipe-Line:—

Pipe per linear ft............	$2.32
Concrete trestles	.18
Railroad	.53
Transportation	.33
$3.36 per lin. ft.	

Telephone Line:—Cost per mile, $4.26

Steel Pressure Line:—Contractors' prices were as follows:

5/16-in............	$5.50 per ft.
3/8 -in............	6.25 per ft.

The city did the earth excavation and backfilling at the following cost:

Earth excavation, per cu. yd............	$ 1.32
Backfilling, per cu. yd............	.55

Humpback Reservoir:—

Earth excavation, per cu. yd............	$ 2.09
Rock excavation, per cu. yd............	12.78
Clearing, per acre............	605.00
Placing gravel in bottom, per cu. yd............	2.48
Concrete foundations for dam, per cu. yd............	9.00
Concrete in dam, per cu. yd............	10.05

These prices included plant, tools, equipment, supplies, bookkeeping, etc.

As previously mentioned, Mr. Wynn Meredith of the firm of Sanderson & Porter of New York, was consulting and designing engineer, and had charge of the construction. He was represented on the ground during the progress of the work by Mr. Boyd Ehle.

General Data.—The following data in connection with this work may be of interest:

Area of Sooke Lake at 655-ft. elev. city datum, acres......	978
After 12-ft. rise, area, acres............	1,180
Land clearing around the lake, acres............	300
Length of concrete flow-line 42-in. in diameter, ft..........	144,040
First pipe made, April 20; commenced laying, May 16, 1914; finished on May 8, 1915.	
Length of pressure pipe-line 36 in. in diam., ft............	56,677
Started to manufacture in July, 1914; finished laying, January, 1915.	
Total quantities of earth excavation, cu. yd............	180,342
Total quantities of rock excavation, cu. yds............	150,517
Cost of construction, including engineering, etc............	$2,037,176
Cost of land, which includes right of way for pipe-lines, site for Humpback Reservoir, land adjoining Sooke Lake and the Sooke Lake drainage area............	$540,000

Supplementary Cost Data.—The foregoing matter is all taken from Mr. Rust's paper before the A. S. M. I. What follows is from an article published in The Canadian Engineer of Dec. 23, 1915, based on notes furnished that journal by Mr. Rust.

It will be remembered that the original contractors abandoned the work in April, 1914, after working slightly more than twelve months, and Mr. Rust then, as water commissioner, took charge of the work and completed a great deal of it by day labor.

The contract was divided into five schedules: Schedules A and B comprised the clearing of land, construction of roads and the dam at Sooke Lake; Schedule C, the concrete pipe line; Schedule D, work in connection with the Humpback reservoir; and Schedule E, work on the pressure pipe line from the Humpback reservoir to the city.

SCHEDULE A.

	Contractor's figures.	Actual cost.
Earth excavation, cu. yd............	$ 1.50	$ 0.22
Rock excavation, cu. yd............	7.50	4.67
*Clearing land, per acre............	150.00	246.10
Building wagon road, cu. yd............	1.50	0.89

SCHEDULE B.

	Contractor's figures.	Actual cost.
Earth excavation, cu. yd............	$ 0.70	$ 0.90
*Rock excavation, cu. yd............	4.75	3.44
†Concrete, cu. yd............	11.00	15.69

SCHEDULE C.

	Contractor's figures.	Actual cost.
Clearing right of way, per mile............	$2,400.00	$1,456.00
Earth excavation, cu. yd............	.60	.57
Rock excavation, cu. yd............	1.75	1.79
‡§Concrete pipe, lin. ft............	2.53	‖3.35
‖This includes the construction of railway, concrete trestles and transportation. The pipe per foot under new contract was $2.29 laid and installed.		
‡Telephone line, per mile............	$280.00	$426.00

SCHEDULE D.

	Contractor's figures.	Actual cost.
*Earth excavation, cu. yd............	$ .65	$ 1.92
*Rock excavation, cu. yd............	4.00	11.25
Clearing, per acre............	350.00	445.00
†Gravel on bottom of reservoir site, cu. yd..	1.00	3.28
†Concrete, Class "A," cu. yd............	12.50	**
†Concrete, Class "B," cu. yd............	10.00	**
†Concrete, Class "C," cu. yd............	9.25	**

**Average cost of 3 classes, $9.04 cu. yd.

SCHEDULE E.

	Contractor's figures.	Actual cost.
†Earth excavation, cu. yd............	$ .60	$ 1.32
†Rock excavation, cu. yd............	3.00	9.20
†Backfilling, cu. yd............	.15	.55
*Concrete, cu. yd............	20.00	19.58
‡5/16-in. riveted pipe, lin. ft............	5.25	5.53
‡3/8-in. riveted pipe, lin. ft............	6.25	6.28

*Work commenced by contractor and completed by city.
†Work carried out entirely by city.
‡New contracts awarded.
§Original contract provided for a pipe 40 in. diameter, but new contractor laid, without additional cost, a pipe 42 in. in diameter.

Unskilled labor, 34½ ct. per hour. Eight hours constituted a day's work.

CHOOSING SEWER MATERIALS IN PORTLAND, ORE.

The amendment to the Improvement Code of Portland, Ore., made in 1911, which requires that in sewer construction cement pipe be specified wherever vitrified clay pipe may be used, has frequently led to absurdity, says R. G. Dieck, Commissioner of Public Works, in his latest published report, since, with high velocities, best engineering practice does not regard unprotected cement pipe as the equal of vitrified clay pipe. Convinced of the superiority of vitrified clay pipe on steep grades, the department has, in such instances, recommended use of this pipe in preference to cement pipe and has, thereupon, been subjected to unpleasant criticism and controversy. The provision as drawn is sweeping in terms and, in utter disregard of practical experience, unquestionably declares that both types of pipe are of equal serviceability under all conditions.

Cement Pipe versus Monolithic Construction for sewers of large diameter has also been a question in issue. Upon stable foundations and with adequate protection of the invert against scour, these types are practically equivalent in service, except that the construction of monolithic sewers may be more closely inspected and that pipe sewers are adjustable to alignment without delays in construction of forms. On the other hand, in unstable foundations, leakage of sewage into the subsoil at the numerous joints of pipe sewers follows settlement, and adjustments in the soil without movement of the sewer itself are scarcely possible, whatever may be the type of joint or the character of workmanship. Generally, the bids for monolithic construction have been lower than those for pipe sewers, but in a recent advertisement for bids the reverse was the case.

In that instance the Department, in the face of a possible economy, recommended award to the monolithic construction, having some doubt as to the character of the foundation. In places where it is undesirable to open long sections of trench in advance of construction, pipe sewer has a distinct advantage over monolithic construction, and in such cases it might be more desirable to make award for a higher priced construction to save inconvenience.

A CONVENIENT OXY-ACETYLENE WELDING OUTFIT.

Figure 1 illustrates an outfit designed to satisfy average requirements for oxy-acetylene welding about garages, machine and railway shops, boiler works, etc. This outfit is made by the Searchlight Co., of Chicago, and contains the following appliances, weighing in the carrying case 28½ lb.:

One searchlight welding torch (20-in. long) with seven interchangeable tips for various thicknesses of material and necessary hose connections.

One searchlight acetylene 3½-in. regulator with 300-lb. high pressure and 50-lb. low pressure gages and necessary cylinder and hose connections.

One searchlight oxygen 3½-in. regulator with 3,000-lb. high pressure and 150-lb. low pressure gages and necessary cylinder and hose connections.

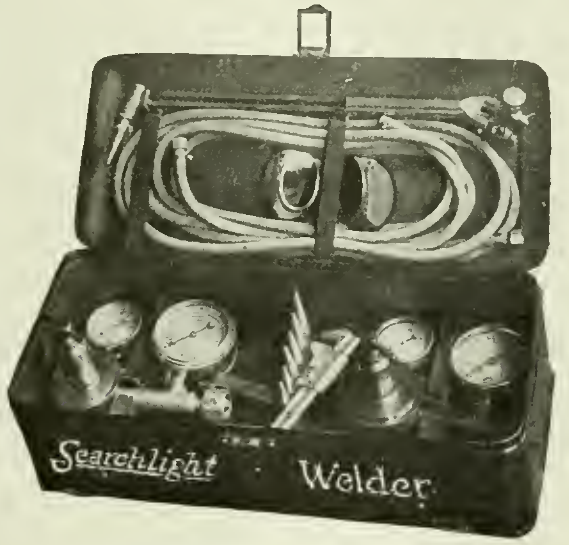


Fig. 1. Oxy-Acetylene Welding Outfit.

One length 10-ft. special high pressure 3-ply hose and clamps for acetylene.

One length 10-ft. special high pressure 3-ply hose and clamps for oxygen.

One wrench for all connections and regulators.

One pair high-grade welding goggles (imported lenses).

One complete book of welding instructions.

MAKING TIGHT JOINTS IN SANITARY SEWERS.

To the Editors: Commenting on "Making Tight Joints in Submerged Sanitary Sewers on Coney Island," published in Engineering and Contracting of Feb. 9, 1916, I would suggest that a mixture of one-half Portland cement and one-half tallow melted and thoroughly mixed together be used in such a case as mentioned. This compound is impervious to water and sets very hard. It has been found in excellent condition after years of use. I do not know what action salt water might have on it, but think it would be very slight, if any. Very truly yours,

RAY D. BAKER, General Contractor.

Highland Park, Mich., Feb. 11, 1916.

COST OF VARIOUS SEWAGE TREATMENT PLANTS IN ILINOIS.

Table I herewith gives cost data pertaining to 19 sewage treatment plants of various types in the state of Illinois. These data are from the report of the Committee on Sewerage and Sewage Disposal of the Illinois Society of Engineers.

The Committee believes that in general too little money has been spent on sewage disposal plants in Illinois. Consequently, many of them are not of sufficient capacity properly to do the work required of them. The result is that some of the plants have not sufficiently relieved the conditions for which they were built.

The Committee believes, further, that the engineer should be the first to advise as to the proper size and capacity of plants, and that he should make his cost estimate sufficiently high to cover a plant of reasonable size and proper loadings to do the work for which it was built.

The members of the Committee are Samuel A. Greely, Chairman; Winfred D. Gerber and Frank M. Connolly. We are indebted to Mr. Gerber for this information.

TABLE I.—COST DATA ON 19 ILLINOIS SEWAGE TREATMENT PLANTS.

City.	Estimated tributary population.	Type of plant.	Cost of construction. Total.	Cost of construction. Per capita.
Moline	5,000	Pump station, Imhoff tanks, disinfection...	$10,700	$ 2.14
La Grange.....	5,300	Pump station, settling tank, sprinkling filter	40,000	7.56
Barrington	1,000	Imhoff tanks and sand filter	6,000	6.00
North Chicago.	3,500	Septic tank and filters.	8,300	2.38
Lake Forest...	3,000	Septic tank and filters.	8,575	2.86
Ft. Sheridan...	1,000	Septic tank, sprinkling and sand filters......	45,990	45.99
Great Lakes...	800	Septic tank and sprinkling filters	35,940	44.80
Morton Grove.	1,200	Imhoff tank and sludge bed	12,815	10.70
Sandwich	2,500	Imhoff tank and sand filters	10,915	4.36
Downers Grove	2,000	Septic tank and sand filters	7,980	3.99
Galva No. 1....	800	Septic tank and trickling filter	3,700	4.62
Galva No. 2....	1,200	Imhoff tank, trickling filters	4,700	3.92
Woodstock	4,350	Septic tank, sand filters	10,874	2.50
Harvard	3,000	Septic tank, sand filters	11,980	3.99
Arlington Hgts.	3,000	Septic tank, sand filters	11,950	3.98
Aledo	2,000	Septic tank, trickling filters	4,500	2.25
Geneva	2,400	Imhoff tank, Fox River	6,500	2.70
Toulon	2,000	Imhoff tank, trickling filters	7,790	3.89
Pana	4,000	Imhoff tank, trickling filters	31,000	7.75

HAULING MATERIALS BY PORTABLE RAILWAY TORONTO TO HAMILTON HIGHWAY, ONTARIO.*

By H. S. Van Scoyoc, Chief Engineer.

To construct a concrete road 18 ft. wide, 6 in. deep at the edges and 8¼ in. at the center, requires practically one ton of material for each running foot of roadway. If the average haul is three miles or more as it frequently is, the handling and transporting of this material is the most serious problem in connection with the work. As an example in this particular case more than 90 per cent of the cost of the sand as it went into the concrete was made up of handling and transportation charges. With 36 miles of road to build the first plan was to secure three yards that would have divided the haul about evenly making it average a little more than three miles. Unloading equipment would have been provided for two yards and one of these outfits moved to the third yard. Unforeseen difficulties prevented this, however, and delays in getting the yards in working order made more yards desirable. Materials have been unloaded at six different points. To transport the material an industrial railway outfit was purchased consisting of about 20 miles of sectional track, 24 in. gage, three 7½-ton steam locomotives and 110 1½ cu. yd. V shaped dump cars.

In three of the six yards the sand and stone were unloaded by locomotive cranes and hauled by the dinkeys; in one yard the material was unloaded by hand and hauled by teams in dump wagons; in another it was unloaded by hand into dump cars and hauled by teams on the Industrial track; in the other it was unloaded by hand into the dump cars and hauled by a dinkey. Four of the yards were operated day and night.

The material was dumped on the sub-grade in two rows—the final dump of stone being with the track on top of the previous dump of stone. Much of the cement was hauled with the track in this position. Where possible hauling material past a mixing outfit was avoided but for a limited period in one instance three machines were worked from one base.

To avoid unloading direct from the railway cars into the small dump cars portable hoppers have been built on flat cars each hopper having a capacity slightly greater than one industrial train load. There are two hoppers with each crane, one for sand and one for stone. Each has two chutes so that two cars are loaded at one time. The hoppers have more than cut in half the time required for loading. They prevent waste in the yards and enable the cars to be loaded evenly preventing waste on the road. They are particularly of value when the number of dump cars is limited.

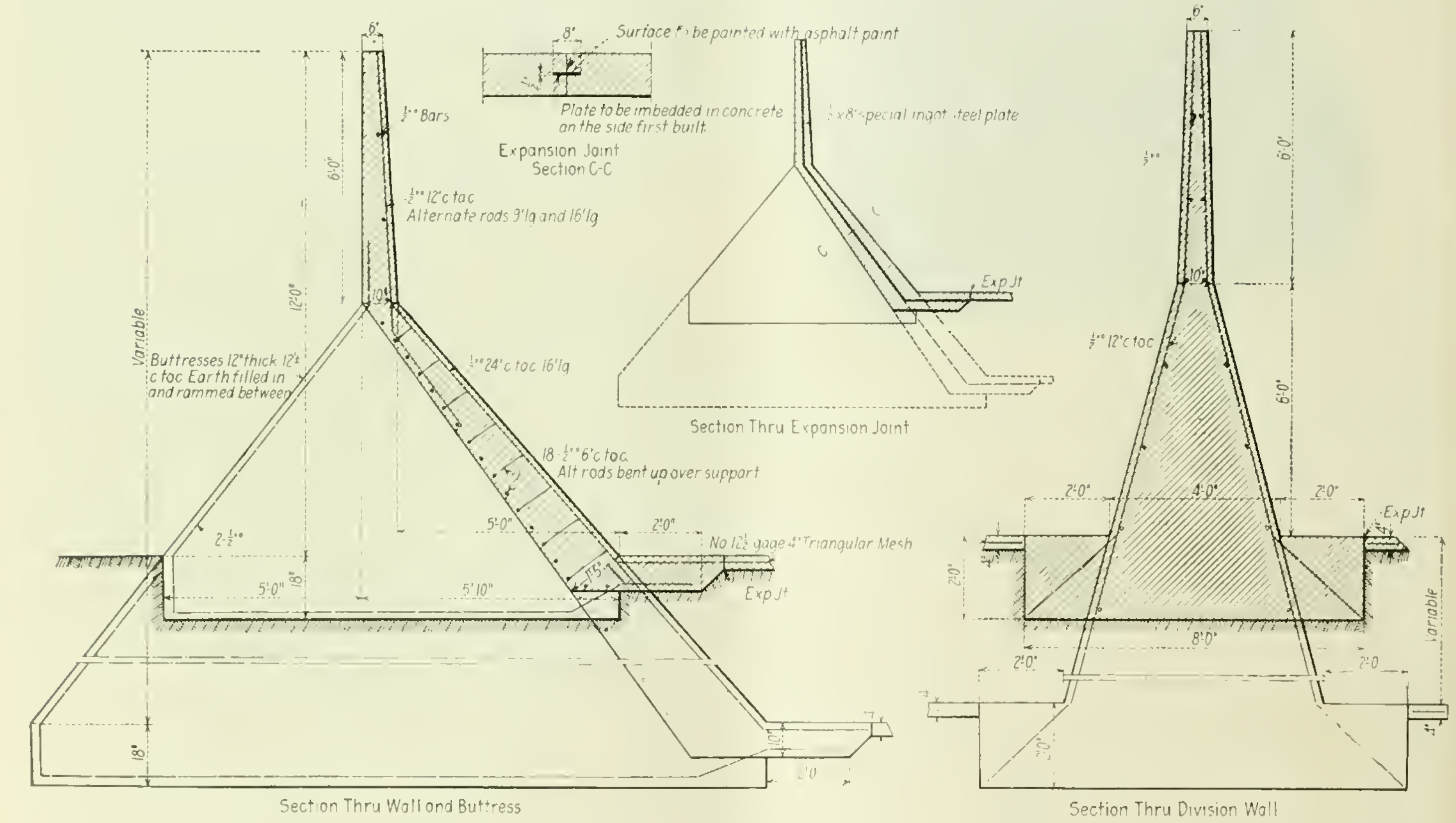
---

*Extract from a paper read before the American Concrete Institute, Feb. 16, 1916.

DESIGN AND CONSTRUCTION OF THE AUSTIN, TEXAS, REINFORCED CONCRETE RESERVOIR.*

By Lamar Lyndon, Consulting Engineer, and Frank S. Taylor, Resident Engineer.

The Austin reservoir is a circular, reinforced concrete structure averaging 12 ft. in depth, 392 ft. in outside diameter, and it has a capacity of 10,000,000 gal. It is divided in four sections by means of two walls, each of which runs across a diameter of the reservoir—these two walls being at right angles to each other, and intersecting at the center of the structure. The general design is indicated by the drawing herewith. The lower 6 ft. of wall is inclined inwardly, the inclination being 5 ft. in the height of 6 ft., as shown. This lower section of wall is supported on a series of external buttresses spaced 12 ft. apart, and the lower wall section spans from buttress to buttress as a simple beam, the thickness of the concrete and the area of the reinforcing steel being computed for simple beam action. The upper section of the wall is vertical, and this is unsupported externally. It acts as a cantilever, and is so designed. A resultant of all the forces acting on any section cuts the base of the buttresses at a point about 4 ft. 6 in. from the outer end, and 6 ft. 8 in. from the inner end. This means that in order to equalize the foundation pressures, the buttress footings are spread near the outer end. A drawing is also shown of the cross division wall. As shown, this is simply a wall battered on both sides, and reinforced as a cantilever. When one division of the reservoir is emptied, this wall must, of course, withstand the water pressure due to 12 ft. depth against it, and as the divisions are alternately filled and emptied this wall must be able to resist a pressure applied on either side. The location and quantities of steel are clearly shown in the drawing.


6'
½" Bars
6'0"
½" 12" c toc
Alternate rods 9' lg and 16' lg
12'0"
Variable
Buttresses 12" thick 12' c toc Earth filled in and rammed between
10½
½" 24" c toc 16' lg
18 ½" 6" c toc
Alt rods bent up over support
2-½"
5'0"
18"
5'10"
2'0"
No 12½ gage 4" Triangular Mesh
Exp Jt
18"
1'0"
8'
Surface to be painted with asphalt paint
Plate to be imbedded in concrete on the side first built
Expansion Joint Section C-C
½x8" special ingot steel plate
C
Exp Jt
Section Thru Expansion Joint
6'
½"
6'0"
10'
½" 12" c toc
6'0"
2'0"
4'0"
2'0"
Exp Jt
2'0"
Variable
8'0"
2'0"
2'0
1'

Section Thru Wall and Buttress

Section Thru Division Wall

Typical Cross-Sections of Reinforced Concrete Reservoir at Austin, Tex.

Expansion Joints.—Two expansion joints were placed in each of the cross walls, there being one joint midway between the rim of the reservoir and its center in each wall. Also there were four expansion joints placed in the outer rim of the reservoir, each joint being midway between the points where the cross walls joined to the rim. Although the circumference of this structure is about 1,200 ft., it was assumed by the engineers that practically no provision was necessary to take care of the expansion of the rim, because of its circular section, and these four expansion joints, dividing it into 300 ft. sections, were merely placed as a factor of safety. It was found that the assumption, that the circular ring would expand and contract without cracking, was incorrect, and, in view of the fact that much of the concrete was cast in the summer time, there should have been double the number of expansion joints placed that were actually used. The first winter, after the construction of this reservoir, cracks appeared at numerous places in the rim, and were not effectually stopped until they were cut out with a cape chisel and grouted together during the cold weather. The expansion joints did not leak at all, and the change in length of the walls, with change in temperature, was clearly visible at the expansion joints.

The expansion joints were simply made by placing a strip of steel plate ½x8-in. in the form and bulk-heading it off, so that when the form was poured full the wall ended at the expansion joint; the concrete adhered firmly to the steel strip, of which 4 in. was inserted in the form, and 4 in. left projecting over the edge of the finished section. After stripping the form, the edge of the concrete and the projecting portion of the steel plate were thickly coated with asphalt, and the next section of concrete cast; thus leaving the two abutting ends of the concrete disconnected, and the steel plate acting like a tongue working in a co-acting groove. This joint is shown in the drawing, and its construction and dimensions are clear. These joints are simple, and have never given any trouble by leakage or otherwise. In order to maintain the monolithic nature of all work on the walls, between expansion joints, it was necessary to pour one-half of each cross wall together with one-fourth of the circumferential wall without interruption. This was accomplished by pouring from scaffolding above the final height of the wall. This scaffolding provided for the runways of concrete cars. Concrete was taken into the cars from an elevated hopper, which was served by a hoist situated above the mixer, near the center of the reservoir in one of the compartments.

---

*From paper before American Concrete Institute.

Form Work.—Forms were provided for one-quarter of the entire construction. The forms to be placed for the inclined beams were supported by lugs held by bolts through the buttresses. These forms were afterwards struck by simply removing the lugs and allowing the forms to fall out. The inside forms for the beam section were braced from posts set firmly in the ground at the bottom, the top was held by bolts through pipe separators to the under form. The outside form of the upper section was placed before concreting was begun. The concrete was run periodically over the entire horizontal area of the beam section of the form until it had reached within a few inches of the height of this section. The upper forms were placed while concrete was being run in other parts of the same monolithic section, so that a continuous and monolithic section was obtained from the foundation to the top of the reservoir between expansion joints.

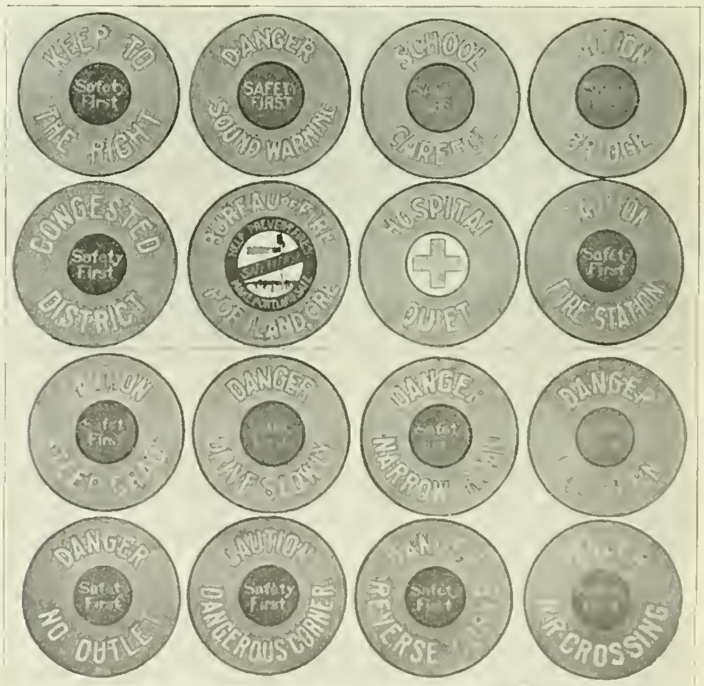
Concrete.—As will be noted from the plan, the thickness of the wall varies from 6 in. to 17 in., and the floor slab is 4 in. It was necessary to provide a concrete that had maximum density in order to assure an impermeable structure. This was obtained by carefully measuring the voids in the aggregate while the concrete was being mixed and the voids always filled with cement. It was provided in the estimate of cement necessary to fill the voids that 8 per cent of the weight of cement of hydrated lime would be used, and that the total volume of the cement and lime would be equal to the voids shown in the aggregate, less 9 per cent of the volume of aggregate allowed for water of crystallization, plus 4 per cent for increased volume due to the further separation of the particles of aggregate by the cement and lime and for imperfect mixing. The separation of the particles of aggregate by the cement was found to be usually less than 1 per cent, but the uniformity of distribution of cement throughout the voids in the aggregate was less certain, and our experience required a safety factor for this item of 4 per cent in the quantity of cement necessary to provide for the voids as tested.

Floor.—The floor or pavement was laid directly on the natural surface, after it had been cleared off, and about 12 in. of loose material removed. Before laying the pavement, a five-ton road roller was moved over it, so that the unit pressures to which the earth was subjected were greatly in excess of those which could be imposed by the weight of the water in the reservoir. This pavement was 4 in. in thickness, except at the expansion joints, where it was made 8 in. thick—the expansion joints being simply overlapping joints, such as are well known in the art. It was decided, after some experimentation, that expansion joints in the floor slabs could be 50 ft. apart with safety, so that the floor or pavement of the reservoir was divided into slabs 50 ft. square. The expansion joints were made by the forms over the part of the joint which projected under the next slab. After these forms were struck, it became necessary to provide an elastic material against the under lip of the expansion joint so that the next concrete poured would not be against that lip by whatever thickness we estimated the expansion of the slab would require. This distance was found to be about ½ in., and the lower lip was provided for by rolling tarred paper to a sufficient thickness to make it the required ½ in. when flattened. This was rolled against the lower lip, and the upper lips were separated by a piece of lumber ½ in. thick. The face of the expansion joint on the first slab run was painted with asphalt before the tarred paper or lumber strip was placed. Before concreting the pavement, 2 in. of sand was placed over the surface to be covered by the pavement, thoroughly wet, and on this sand the reinforcing material, No. 12—4-in. triangular mesh, was sewed together and spread over the entire surface of the slab to be concreted. The concrete was mixed and poured in rows 4 ft. wide, the contact of new concrete with old being separated by a period of time not longer than 12 minutes. As soon as one run of concrete was finished, and the next one begun, a man was provided to follow the run to pull up the reinforcing material into the concrete. This was done by a steel hook about 12 in. long, which the operator thrust into the concrete until he had encountered the reinforcing, after which he pulled it up into approximately the middle of the 4-in. slab. After the concrete had set from two to four hours, depending upon the temperature, other operators with long handled floats, smoothed the surface of the concrete to an approximate plane. This operation proved successful, and, after two years of use, no cracks, or even checks, due to temperature changes, have shown in any of this pavement.

STANDARD WARNING SIGNS ON PORTLAND, ORE., STREETS.

As an outcome of the traffic study made in Portland, a couple of years ago, a safety-first movement was inaugurated by the city which has resulted in placing 265 warning signs bearing 16 different legends, as illustrated herewith. These signs are placed at various points throughout the city. The unit cost of the signs was as follows:

	Labor.	Material.	Total.
Signs 18 in. in diameter	$0.30	$0.31	$0.61
Standards, 1½-in. pipe	.08	.92	1.00
Assembling and erection	.65	.05	.70
Total	$1.03	$1.28	$2.31



Standard Warning Street Signs of Portland, Ore.

The Street Signs previously erected by the city are of baked enamel on sheet metal and, while of very good appearance when new, are not durable in outlying residence districts. When subjected to abuse, the enamel scales and the metal becomes rusty. By painting and varnishing a heavy sheet metal, a much more durable sign has been made at considerably less cost. One hundred and sixty-one such signs were completed at an average cost of 18 ct., compared to 29 ct. for the enameled sign.

CONSTRUCTING A SMALL, STEEL WATER SUPPLY MAIN IN THE PHILIPPINES.

The Singson water works at Vigan, Ilocos Sur, Philippine Islands, were constructed by day labor. These works comprise a small headworks in the mountains, 6.7 miles of steel supply main, a cast-iron distribution system, and a 200,000-gal. reinforced concrete standpipe. This article, based on a general description of these works published in the Quarterly Bulletin, Bureau of Public Works, pertains to the steel pipe line only.

The 6.7 miles of steel main are laid with 5½-in. outside diameter Matheson-Joint pipe, protected with "National" coating, manufactured by the National Tube Co. Standard 5½x5½x2 in. tees were inserted for blow-off and air-valve specials. Crispin 2-in. air valves, inclosed in concrete manholes with wooden covers, were installed in the line.

After leaving the sand box at the headworks, the pipe line passes through very rough country on its way down the mountain side. In the first half mile six trestle bent bridges, with a total length of about 800 ft., were required for supporting the pipe across the numerous ravines and gullies. These bridges were made of bents of an average height of 18 ft., spaced 19 ft. 8 in. apart; they were constructed from left-over lumber used in the sheet piling in the river crossing.

On account of the circuitous route of the pipe line in the hills, the use of steel pipe was found to be very advantageous for the reason that the pipe could be bent to the required curvature in the field. With cast-iron pipe these curves, both horizontal and vertical and sharp in many places, would have required the use of many specials. From the standpoint of leakage also, conditions favor the use of steel pipe on account of the fewer number of joints. The average length of all steel pipe delivered gave a run of 278 joints per mile, while cast-iron pipe would have required approximately 438 joints per mile. This means that the line, if constructed of cast iron, would have had nearly 60 per cent more joints than it now contains. The item of leakage is of the utmost importance to Vigan, especially during the dry season when the flow of the spring is a minimum and the per capita consumption a maximum.

The question of cost, however, was the leading consideration in the choice of a steel main over a cast-iron one. At the foot of the mountain the pressure is approximately 200 lb. per square inch. The use of cast iron for such high pressure would have required an unwarranted expenditure of funds. The saving in the use of steel pipe was about $26,000. The conditions of soil, drainage, and the quality of the water, however, are all favorable for successful use of steel pipe.

On account of the sand and gravel formation in the river section, it was necessary to drive sheet piles for 660 ft. of the crossing in order to bury the pipe below the scour line. All joints, within the sheet-pile section, were calked with lead wool, which was found to produce a stronger and a more flexible joint and is capable of withstanding greater pressure than the ordinary lead joint.

In laying the steel pipe, considerable difficulty was experienced from the expansion caused by the large range of temperature between midday and night. This would have been overcome to a large extent by the insertion of a slip joint at every half mile. After new lengths had been cut in at the points where the pipes had pulled apart and the main immediately filled with water, these new joints gave no more trouble. All of the supply main was tested by the application of 240 lb. pressure per square inch.

DESIGN AND CONSTRUCTION OF THE SUBSTRUCTURE FOR A THREE-TRACK TRUNNION BASCULE BRIDGE IN CHICAGO, ILL.

(Staff Article.)

The Chicago & Northwestern Ry. is replacing an old double-track swing span over the North Branch of the Chicago River, at Deering, with a three-track Strauss bascule bridge of the heel trunnion type. The new structure will provide a clear channel of 145 ft., the axis of the bridge making an angle of 74° with the established pile and timber fenders. The lift end of the bridge is skewed to conform to the established channel of the river, while the trunnion end is square. The trusses of the bascule span have lengths of 174 ft. and 186 ft., respectively, center to center of bearings; they are spaced 45 ft. on centers. The rest pier consists of two cylindrical pier shafts, while the trunnion end of the bridge and its counterweight frame are supported on four pier shafts. All shafts extend to bedrock. The four shafts at the trunnion end of the bridge are all connected by reinforced concrete members; the two rest pier shafts are also braced to form a bent. The approaches to the bascule span consist of deck plate girders. Figure 1 shows side and end elevations of the bridge and indicates the general design features.

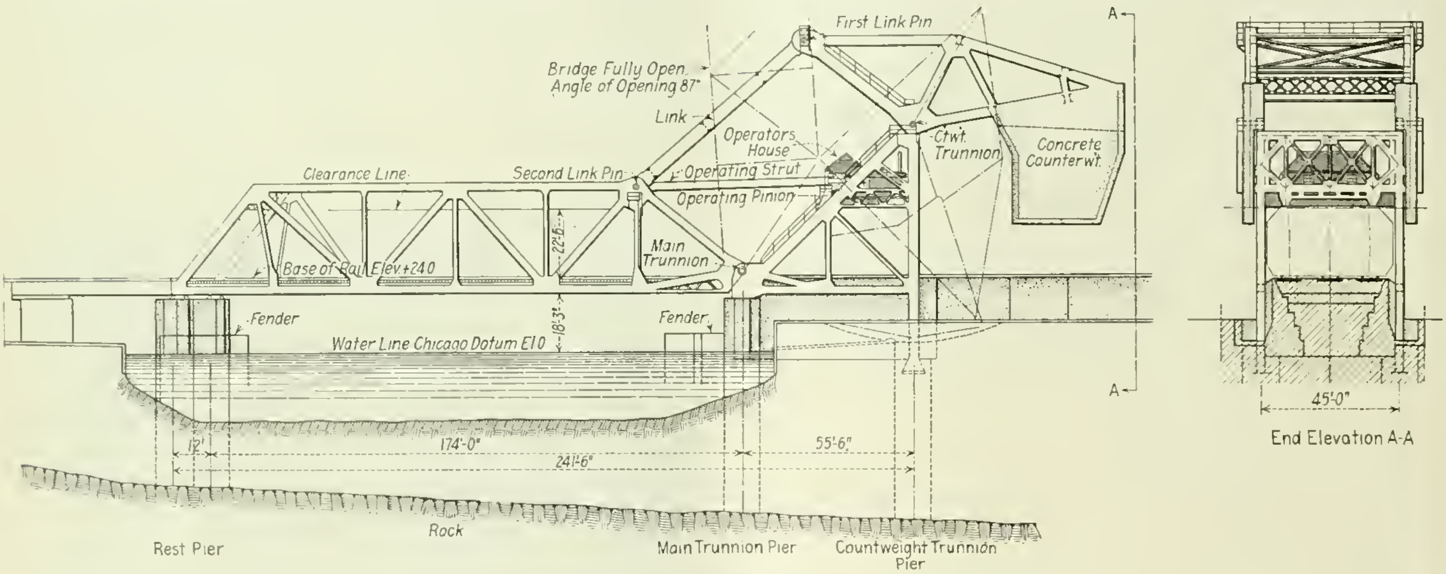
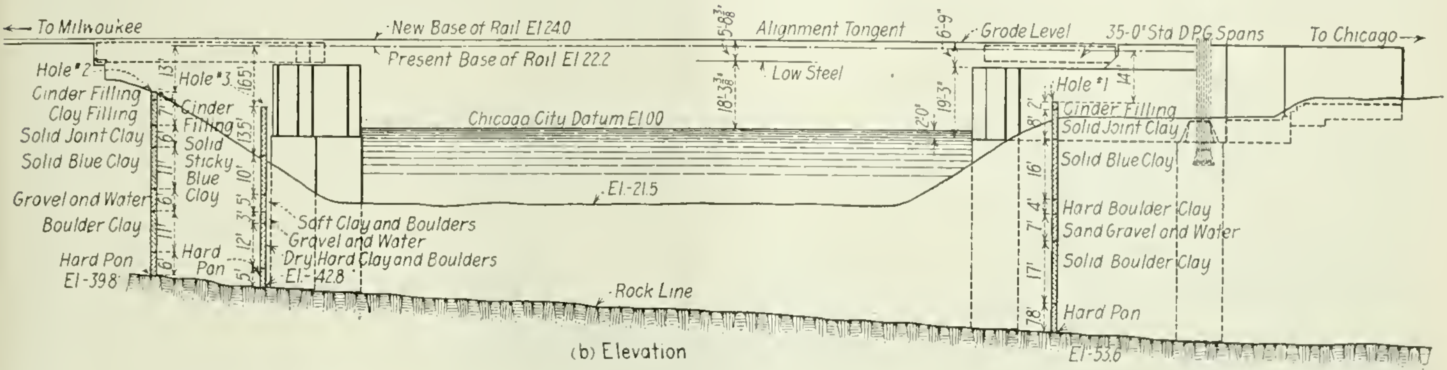


Fig. 1—Side and End Elevations of Three-Track Trunnion Bascule Bridge Over North Branch of Chicago River, Chicago, Ill.

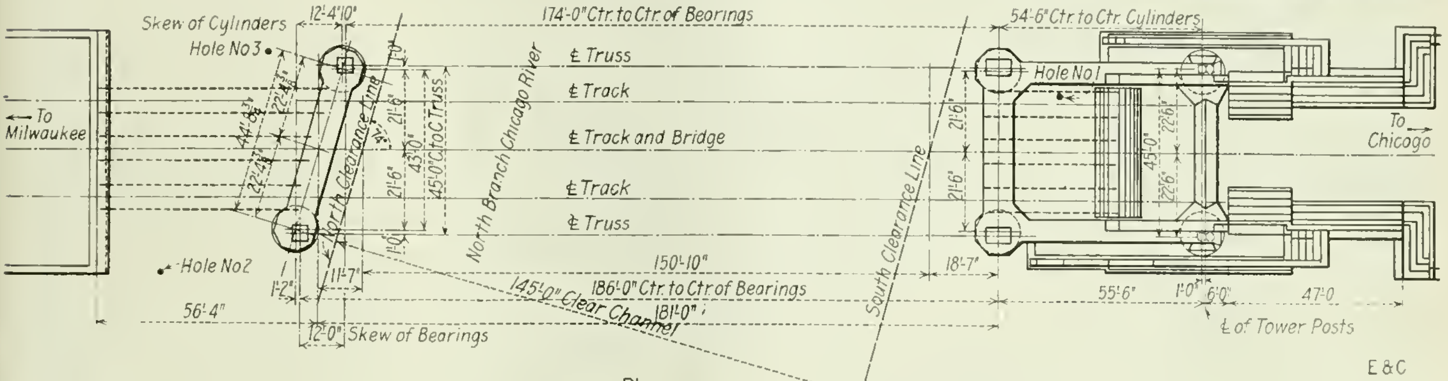
Subsoil Conditions and Design Features.—The general design features of the substructure and the subsoil conditions at the bridge site are shown in the plan and elevation of Fig. 2. The base of rail of the new bridge will be 1.8 ft. above that of the old swing structure and is 24 ft. 0 in. above the water level (Chicago City Datum, elevation 0.0). At the bridge site the river will be excavated to a depth of 21 ft. 6 in. At the site of the rest pier bedrock lies at a depth of 42.8 ft. below the water level, or 66.8 ft. below the new base of rail. At the pier shafts at the trunnion end of the bridge bedrock lies at a depth of about 54 ft. below the water level, or about 78 ft. below the base of rail.

Before starting excavation work for the pier shafts borings were taken at three points, two near the rest pier and one near the main piers at the other end of the bridge. The results of the latter boring (No. 1, see Fig. 2 b) were as follows, beginning at the ground surface: cinder filling, 2 ft.; solid joint clay, 8 ft.; solid blue clay, 16 ft.; hard boulder clay, 4 ft.; sand, gravel and water, 7 ft.; solid boulder clay, 17 ft.; hardpan overlying bedrock, 7.8 ft. The character of the material encountered at the other two borings is substantially the same as that given for boring No. 1, although the depth to bedrock is considerably less.

Rest Pier.—As has been noted, the axis of the rest pier forms an angle of 74° with the longitudinal axis of the bridge. This pier consists of two concrete cylinders, 12 ft. in diameter, tied together at the top with a concrete member 8 ft. wide and 19 ft. 3 in. deep, the latter being reinforced with two steel trusses 16 ft. deep and with reinforcing bars. Above a plane 2 ft. below the water level these pier shafts are octagonal in shape. The top of this pier is 6 ft. 9 in. below the new base of rail. Figure 3 shows details of the rest pier.

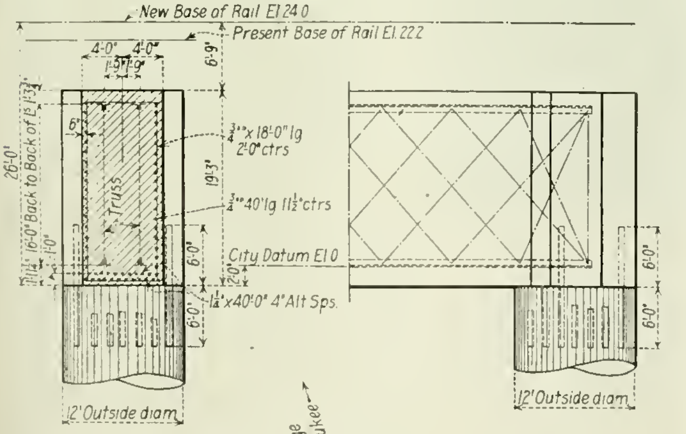


(b) Elevation

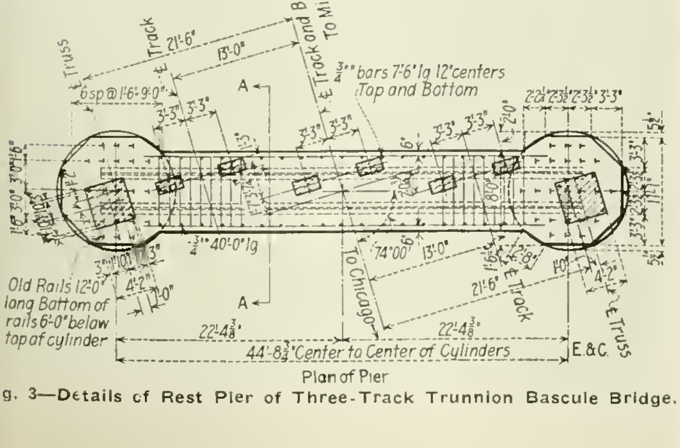


(a) Plan

Fig. 2—General Plan and Elevation of Substructure of Three-Track Trunnion Bascule Bridge, Showing Design Features and Subsoil Conditions.



Section A-A Half Elevation



Plan of Pier

Fig. 3—Details of Rest Pier of Three-Track Trunnion Bascule Bridge.

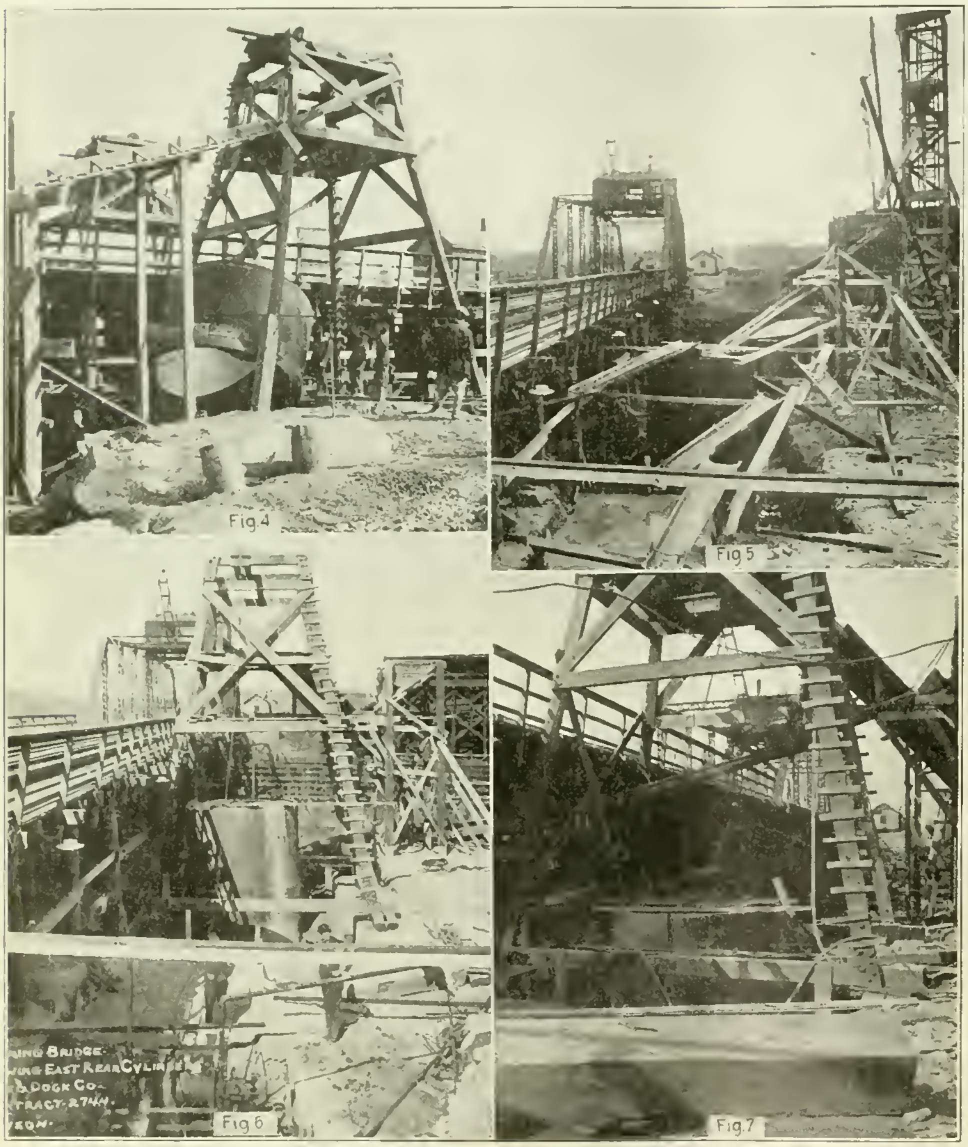
Main Piers.—In its raised position the bascule span is carried on four cylindrical pier shafts, each 12 ft. in diameter, extending to bedrock. The centers of these pier shafts form a rectangle whose longer side (parallel to the longitudinal axis of the bridge) has a length of 54 ft. 6 in., and the shorter side 43 ft. The top of the front pair of shafts, which pair is under the main trunnion, is 6 ft. 9 in. below the new base of rail, while the top of the rear pair, located under the counterweight trunnion, is 2 ft. below the water level, or 26 ft. below the base of rail. Structural steel columns extend from the counterweight trunnion into the rear pier shafts.

The tops of the four pier shafts are tied together with deep concrete struts, which are reinforced with both steel trusses and bars. The strut connecting the main trunnion pier shafts is 8 ft. wide by 19 ft. 3 in. deep, while that connecting the counterweight trunnion shafts is 6 ft. wide by 21 ft. deep. The longitudinal struts are each 6 ft. wide by 19 ft. 3 in. deep.

Counterweight Pit and Timber Fenders.—To form a protection for the counterweight, when the span is open, concrete pits are built as indicated in Fig. 2. These pits consist essentially of concrete retaining walls of the gravity type with spread footings and a reinforced concrete paving over the area directly under the path of the counterweight. These walls have a maximum height of 10 ft. 6 in. and are surmounted by a steel picket fence. They extend for a distance of 89 ft. along and in the rear of the main and counterweight trunnion piers. The concrete paving is reinforced with No. 4 American Steel & Wire Co. mesh.

The design includes an 80-ft. line of pile and timber fenders at each side of the channel, together with a 19-pile cluster at each end of the fenders and intermediate bracing clusters of 7 and 12 piles each. These fenders provide a clear channel of 145 ft. and are placed at an angle of 74° with the longitudinal axis of the bridge. Each line consists of two rows of piles, with two rows of 12x12-in. waling pieces between the piles and two lines on the channel side of them, the upper line of which consists of 12x12-in. timbers and the lower line of 8x10-in. timbers. These fenders extend 6 ft. above the water level, while the pile clusters are 4 ft. above the fenders.

Construction Features.—After a few feet of the top soil had been removed, to form the outline of the pier shaft, the excavation was, in each case, continued inside of a steel cylinder. This cylinder was 12 ft. in outside diameter and was made of $\frac{3}{8}$-in. steel in 8-ft. vertical sections, the sections being added as the sinking progressed. Air pressure was not required in excavating, as the material was, in general, not water-bearing. The working chamber had a height of 8 ft. and it was reinforced with eight vertical diaphragms, each of which was triangular in shape and was constructed of a $\frac{3}{8}$-in. web plate outlined with two $3\frac{1}{2}$x$3\frac{1}{2}$x$\frac{3}{8}$-in. angles. The bases of these diaphragms were riveted to a circular plate, $\frac{1}{2}$ in. thick, which formed the roof of the cutting chamber. This plate had a circular hole in its center for the material shaft which was 3 ft. in diameter. Each of the four shells for the main piers had a length of about 52 ft., while the two shells for the rest pier were about 39 ft. long.



PROGRESS VIEWS ILLUSTRATING METHODS AND EQUIPMENT USED IN CONSTRUCTING SUBSTRUCTURE OF THREE-TRACK TRUNNION BASCULE BRIDGE.

Fig. 4—Placing 8-foot Lower Section of 12-foot Diameter Steel Shell. Fig. 5—Loading Sections of Steel Shell to Facilitate Sinking; Concrete Placed Between Steel Shell and Its Material Tube; Concrete Spouted from Floating Plant Into Land Hopper, Thence Into Steel Shell. Fig. 6—Head Frame in Place for Excavating Material Inside of Steel Shell; Hoisting Engine in Foreground; Land Concrete Hopper at Right. Fig. 7—Excavating Within Steel Shell; Material Dumped Into Inclined Runway Which Ends at Barge in River; Spouting Concrete From Land Hopper to Pier Shaft Opposite That Shown in View.

The 8-ft. sections were brought to the site on barges and then unloaded and transferred to position. They were set in position under the head frames, as shown in Fig. 4, which is a view taken just before a lower section of the shell was set in place on its cutting edge, the latter having been set in the ground in advance.

After the section of steel shell had been set in place, together with its length of material shaft, it was loaded with concrete to facilitate its sinking. The concrete was mixed and hoisted by a floating concrete plant, moored adjacent to the work. Figure 5 is a view showing the concreting operations in connection with the loading of the first section of shell; this view also shows the present double-track swing span. By referring to Fig. 5 it will be noted that the concrete was spouted from the distributing hopper of the floating plant into a land hopper supported on a wooden frame. From the latter it was spouted direct into the steel shell. This use of an intermediate land hopper has proved to be very effective, as it insures a continuous run of concrete and renders the chuting operations much easier than when handled direct from the floating plant. The fluctuations in water level, the back wash, wind conditions, etc., were found very troublesome when the intermediate hopper was not used. The floating plant consists of a deck scow, at one end of which there are mounted a $\frac{3}{4}$-cu. yd. mixer, a hoisting engine, and a 65-ft. tower fitted with a boom, discharge pipe, etc.; at the other end of the scow there is a revolving derrick equipped with a 2-cu. yd. bucket, which serves to feed materials to the concrete plant.

After the shell section had been loaded with concrete a head frame was set up over it and the excavated material hoisted through the air-lock shaft, in buckets operated by a hoisting engine located near the pier shaft. Figure 6 is a view of the same shell shown in Fig. 5, the head fram now being in position for excavating within the shell; the hoisting engine and the land concrete hopper are also shown in this view. The excavated material was hoisted to the top of the head frame, from which it was dumped onto an inclined runway extending from the head frame to a barge in the river. Figure 7 shows the arrangement at a pier shaft for excavating and discharging the excavated material into barges; this view also shows the land concrete hopper and a line of chutes in place for concrete, the pier shaft opposite that shown in the view. Work is still in progress on the foundation of this bridge.

Personnel. — The substructure for the Strauss bascule span was designed by the Engineering Department of the Chicago & Northwestern Ry., W. H. Finley, chief engineer. It is being constructed by the Great Lakes Dredge & Dock Co., under the supervision of H. M. Spahr, resident engineer for the railway company.

Iowa State Drainage Association.—The twelfth annual meeting of the Iowa State Drainage Association will be held at Fort Dodge on Thursday and Friday, February 24 and 25, 1916. A good program of papers has been prepared and there will be several committee reports. Drainage engineers are requested to bring samples of drainage maps and plans. Manufacturers of instruments, appliances, equipment and supplies are invited to arrange for their exhibition. Mr. M. F. P. Costello is secretary, Fort Dodge, Ia.

GOOD PRACTICE IN CONCRETE ROAD CONSTRUCTION.*

The Second National Conference on Concrete Road Building adopts the following principles as representing good practice in the construction of concrete roads and pavement.

Drainage.—The drainage of the roadbed is of vital importance. If the subgrade is not well drained, there is danger of unequal settlement or frost action, which will cause cracks. The method of drainage to be used will depend on local conditions. For roads proper drainage may be secured through lateral ditches. For streets, as well as roads, tile drains may be used which should be laid on each side of the roadway, or on one side only, with cross drains leading thereto at a suitable depth, depending on the width of the pavement. Drainage trenches, if placed under the subgrade, should be completed before final rolling.

Grading.—When roadways are constructed over fills extreme care should be observed to insure the use of proper materials in layers of such thickness that they may be thoroughly compacted so that when the fill is completed there will be a minimum of settlement. In general, fills shall be made in thin layers, the depth depending on the character of material to be used in making the fill. The fill should be allowed to stand for as long a time as possible, giving it an opportunity to settle thoroughly before the pavement is placed thereon. Deep fills should be allowed to settle through one winter wherever such procedure is possible. Puddling will be found advantageous in compacting deep fills. Wetting and rolling shall be performed when making a fill in order to secure thorough compactness. Fills should never be made with frozen materials nor with lumps greater than 6 in. in their greatest dimension.

Subgrade.—The fundamental requirement of the subgrade is that it should be of uniform density so that it will not settle unevenly and cause cracks in the surface of the pavement. No part of the work is more worthy of intelligent care and painstaking labor than the preparation of the subgrade. The slight additional cost necessary to insure good results is abundantly justifiable. When the pavement is constructed on virgin soil, care should be taken to remove all soft spots so as to insure a uniform density; and if constructed on an old roadbed, even greater care must be taken to secure uniform density, as the subgrade is likely to be more compact in the center than at the sides. An old roadbed should be scarified, reshaped and rolled. The subgrade adjacent to curbs should be hand tamped.

Portland Cement.—Portland cement shall meet the requirements of the Standard Specifications for Portland cement of the American Society for Testing Materials and tests should be made in accordance with the methods of tests outlined by the American Society of Civil Engineers.

Aggregates.—The selection of proper aggregates for concrete road construction is of utmost importance. Clean, hard, well graded materials are absolutely essential to success. For this reason samples of the materials proposed for use should be submitted to the engineer for approval before orders are placed. These samples should be carefully inspected; and, if possible, laboratory tests made to determine their suitability. If laboratory tests on shipments cannot be made, field tests can be used to furnish a general indication of quality. The different aggregates should be kept clean and separate.

Aggregates to be used in the wearing course of two-course pavements should never be placed on the subgrade, but on planks or some other means provided to keep them free from dirt. When aggregates are placed directly on the subgrade care should be used by the shovelers to avoid getting clay or earth shoveled from the subgrade into the mix. Aggregates should not only be clean when they are delivered on the job, but clean when placed in the mixer.

Water.—Water supply is a most important factor and is frequently overlooked by the engineer and contractor. A large supply of water is necessary for (a) sprinkling the subgrade; (b) mixing the concrete; and (c) keeping the concrete moist during early stages of hardening. For this latter purpose 25 to 30 gal. per square yard of pavement will be required during the summer months. Insufficient sprinkling is detrimental to the wearing qualities of the pavement.

Reinforcement.—The use of reinforcement in concrete pavements is increasing. A coating of light rust will not be detrimental to satisfactory results, but care should be exercised that no excessive rust, paint or other coatings are present to interfere with proper bond. Care should also be exercised to see that the reinforcement is so stored, prior to use, that it is not covered with mud or clay when placed in the pavement. Reinforcement left on a job when contract is not completed at the end of the season should be collected and stored so that it is protected from the elements. Occasional tensile and bending tests should be made to see that the requirements of the specifications are fulfilled.

Joint Filler.—Joint filler should preferably be of a single thickness. Transverse joint filler should be cut to the crown of the pavement by the manufacturer when metal plates are used. A type of joint filler which will iron out readily under traffic is preferable for use in unprotected joints. A joint filler which will not bend easily when concrete is deposited against it is to be preferred.

Joint Protection Plates.—Metal joint-protection plates should be properly bundled and wired by the manufacturer so that they will arrive on the work in good condition, free from warp. Protection plates up to 20 ft. shall be shipped in single lengths. The exact length should be provided so that the contractor will not find it necessary to cut plates. In cutting plates for length, spacing between eccentrics on the installation bar should be considered to avoid interference with anchorage lugs on plates. Particular care should be used by the manufacturer in crowning the installing bar, to avoid the necessity of duplication of work by the contractor.

Forms.—Metal forms of sufficient strength to withstand the necessary hard usage are preferred. When wooden forms are used they should be of at least 2-in. stock and capped with a 2-in. angle iron, so constructed that adjacent sections can be lapped. Forms should have a width not less than the thickness of the pavement at the sides. Particular care should be exercised to see that the top edge of forms are clean so as to avoid unevenness in the finish pavement. If forms are warped or stakes are not properly placed, a poor alignment of the edge of the concrete slab will result.

Thickness.—The thickness of a concrete road or pavement is controlled by many factors, each of which should be given consideration. In view of the increasing use of the heavy motor truck, it seems unwise to build pavements with a thickness of less than 6 in. In general, pavements shall be thicker at the center than at the sides. Alleys with an inverted crown and narrow one-slope roads should have a uniform thickness. Wherever the thickness can be increased without excessive cost, to secure a flat or nearly flat subgrade, such increase is advisable.

Width.—The minimum width for single-track road should be 10 ft. The minimum width of double-track roads should be 18 ft. The total width of the roadway should not be less than 20 ft. for single-track roads and not less than 26 ft. for double-track roads.

Crown.—The crown of roads and pavements should be not less than one one-hundredth nor more than one-fiftieth of the total width. Except in unusual cases, one one-hundredth will be sufficient for country roads and one-fiftieth will be considered satisfactory for alley pavements. For city streets an average crown of one-seventy-fifth will generally be found sufficient and should not be reduced, except on grades.

Transverse Joints.—Joints should be placed across the pavement perpendicular to the center line about 50 ft. apart. There seems to be a tendency to widen the distance between joints. Joints should extend entirely through the pavement as well as through the curb if integral curbs are used. Joints should be constructed perpendicular to the surface of the pavement to avoid the possibility of one slab rising above the other.

---

*Report of the Committee on Resolutions of the National Conference on Concrete Road Building.

Longitudinal Joints.—Longitudinal joint filler should be staked or otherwise securely held against the curb. Joint material should also be placed around manholes, catchbasins, etc.

Protected Joints.—The tendency of present practice is toward the omission of metal protection plates for joints. It is possible that the value of metal protection plates is dependent somewhat on the character of aggregate used, and it is considered that they are more essential in street pavements than in country highways.

Plates.—Plates for protected joints should be wired together with the joint filler in place and securely held in the installing bars. When short sections of joint filler are used they should likewise be wired together. Supports for the joint should be used when the pavement is of such width that the installing bar deflects. On wide streets every joint should be checked as to crown with sighting T's. When necessary to have joint plates in two sections, the contractor should arrange with the manufacturer to have holes drilled in the abutting ends of the plates so that the plates may be securely wired or strapped together. As the joint plates usually do not fit tight to the installing bar, a quarter-inch shim is placed under each end of the installing bar, to insure that the plates are not covered by the concrete.

Measuring.—The method of measuring materials for the concrete, including water, should be one which will insure accurate proportions of each of the ingredients at all times. It is recommended that a sack of Portland cement, containing 94 lb. net, be considered the equivalent to 1 cu. ft.

Proportioning.—The proportions should not exceed five parts of fine and coarse aggregate to one part of Portland cement, and the fine aggregate should not exceed 40 per cent of the mixture of fine and coarse aggregates.

Aggregates.—Proportioning based on sieve analysis or by relative density tests is not practical for concrete roads except where laboratory direction is available; but where proper facilities are available the above proportions may be varied as the tests warrant.

Mixing.—The ingredients should be mixed in a batch mixer of approved style, and the size of the batch should not exceed the rated capacity of the mixer. The mixing should be continued for at least one minute after all the materials are in the mixer and before any of the concrete is discharged. The speed of the mixer should not exceed 16 revolutions per minute; however, the time and not number of revolutions should be the gage of proper mixing.

Consistency.—The practice is to mix concrete entirely too wet. The consistency should be such as not to require tamping, but not so wet as to cause the separation of the mortar from the aggregate in handling and placing. The strength and wearing qualities of the concrete are vitally lessened by an excess of water in mixing.

Placing.—If the subgrade has been disturbed by teaming or other causes, it should be brought to its former surface, and thoroughly saturated with water. The concrete should be deposited rapidly to the required depth and width. The section should be completed to a transverse joint, without the use of intermediate forms or bulkheads, or a transverse joint may be placed at the point of stopping of the work. In case the mixer breaks down the concrete should be mixed by hand to complete the section. Where reinforcement is used it should be embedded in the concrete before the concrete has begun to set; and the concrete above the reinforcement should be placed within 20 minutes after the placing of the concrete below. In two-course pavements the top should be placed within 20 minutes after the placing of the bottom.

Finishing.—The surface of the concrete should be struck off by means of a template moved with a combined longitudinal and transverse motion. The excess material accumulated in front of the template should be uniformly distributed over the surface of the pavement except near the transverse joint, when the excess material should be removed. The concrete adjoining the transverse joint shall be dense and any depressions in the surface shall be filled with concrete of the same composition as the body of the work. After being brought to the established grade with a template, the concrete should be finished, from a suitable bridge, with a wood float to true surface. A metal template should not be used. Brooming of the surface is not necessary and grooves are objectionable even on grades.

Retempering.—Retempering of motar or concrete which has partially hardened; that is, mixing with additional materials or water, is strongly condemned and should not be permitted.

Protection and Curing.—Even the best concrete may be seriously damaged by too rapid drying out, early exposure to low temperature, or by being opened to traffic at too early a period. Hot sun and drying winds are most liable to dry out the concrete too rapidly, thus causing shrinkage cracks or causing a surface which will not wear well under traffic. The use of a canvas covering will be found effective in overcoming this condition. Sprinkling should also be employed as soon as the concrete is hard enough to prevent the surface being pitted. An earth covering or protection by ponding should be employed after the first day. Under most favorable conditions such protection should be given the pavement for at least two weeks. Water should be added during this period to keep the concrete wet. In cool weather it is often advisable to omit the earth covering, thus allowing the concrete to harden more rapidly. Sprinkling should not be omitted during the day in case the surface shows a tendency to dry out. When there is danger of frost, sprinkling should be omitted and a covering of canvas or straw and canvas used. Placing concrete in temperatures at or near freezing is not advisable, and if in special cases, such work is unavoidable, the water and aggregate should be heated and fresh work protected, and precaution taken to protect the concrete from injury for at least ten days. Chemicals to lower the freezing temperature of the mixture should not be used. Concrete should not be deposited on a frozen subgrade.

Opening to Traffic.—Under most favorable conditions a concrete pavement should not be opened to traffic in less than two weeks and when conditions permit this interval should be at least four weeks.

One-Course Pavement.—Where the materials most readily available are such as to give good construction in one-course pavement, this convention recommends that the one course be used.

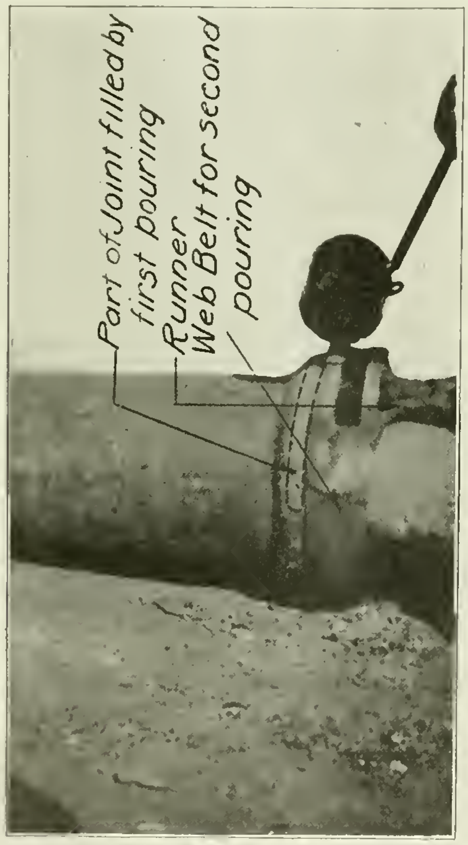
Integral Curb.—The integral curb for concrete street pavements is recommended in preference to straight curb or combined curb and gutter. Such construction eliminates the longitudinal joint along curb, maintains a permanent grade and alignment. Precaution should be taken to insure that the curb is thoroughly bonded to the pavement proper. The integral curb can be used on wide as well as narrow streets.

Specifications.—Since no specifications were considered by the Conference the Standard Specifications for Pavements and Roadways of the American Concrete Institute are recommended.

METHODS, COST AND RESULTS OBTAINED IN THE USE OF ASPHALT FOR JOINTS IN TILE PIPE SEWERS.

Contributed by Paul E. Green of the Engineering Firm of Marr, Green & Co., Chicago.

Leaky Cement Joints.—One of the problems continually vexing engineers engaged in planning sewer systems is the question of tight joints in vitrified tile pipe sewers. The usual method is to have cement joints, reinforced in wet ground with jute. It is a common thing to hear sewer men and masons tell what tight joints they can get with cement, and unquestionably such joints can be secured if sufficient care is taken with the work. Practically, however, all cement joints leak badly. In fact, the writer has never seen a system of tile pipe sewers laid with cement joints that had a less infiltration of ground water than 20,000 gal. per day per mile of sewer, and in bad ground has known this to amount to 100,000 gal. per mile. The question has been discussed over and over again by engineers, and it is the consensus of opinion that about all the water that gets to a tile pipe sewer will get through these joints. The trouble is one of workmanship, for in bad wet ground it is very difficult to get careful workmanship on these joints even if the water is kept well down by pumps. There is so much dirt, mud, sand, mush, etc., that the moment a joint is formed it is liable to be washed out, and human nautre is such that after the joint has been fixed once or twice the workmen will almost invariably pass on to the next one no matter what the condition is. To get perfect joints under such circumstances would require an inspector standing right on top of the workmen every minute of the day, and another inspector to watch the first inspector.


Part of Joint filled by first pouring
Runner
Web Belt for second pouring

Equipment and Sequence of Operations in Repairing Defective Asphalt Joint in Clay Pipe Sewer at Postville, Ia.

It has been stated that the admission of ground water is not an unmixed evil, in that the ground water flushes the sewers while the system is new and before there are many connections, and that in the course of a year or two enough sediment is deposited in the joints to practically seal them. This is very questionable. In fact, the infiltration is more likely than not to increase as time goes on.

Advantages of Asphaltic Joints.—For many years there has been a sporadic use of asphalt or bitumnious compounds to make joints in sanitary sewers, but there does not seem to be much data on the subject. It is not of much use to get tight joints unless the entire system is tight, and the entire system includes not only the main sewers but also all house connections. Hence the use of any such compound as asphalt or tar is of no avail if the municipal corporation does not require that all house connections shall be laid in the same manner. Presuming that such is done, the leakage in bad, wet soil can be reduced to a negligible factor. If the system of sewers discharge on a disposal plant this advantage is very great, or if all the sewage must be pumped either to a free outlet or onto a sewage disposal plant the saving in dollars and cents is a large item, when it is considered that the expense of pumping is a constant one that will always be with the municipality.

In the matter of the disposal plant alone, the load is reduced very greatly by having tight joints. The size of the sedimentation tank, of whatever type, can be more accurately figured and the entire plant can be more satisfactorily and economically designed.

Since there can be no argument about this advantage the question simmers down to one of practicability. This practicability is decided by the items of cost, life of the joints and ease of application of such a compound in making the joint. In the past the cost of a first-class asphaltic compound has been very high, about $85 per ton. This means the joint of a 12-in. pipe will cost, for material alone, about 15 ct., or if the joints are every 2 ft. this means an expense for jointing of 7½ ct. per foot, or 5 ct. per foot if laid in 3-ft. lengths. As against this the cost of a cement joint is not ordinarily more than 1 ct. per foot. It is probable that if the practice increases of using bituminous joints that this cost will be radically reduced, and in fact the writer now understands that a first-class compound can be bought for about $45 per ton.

The essentials of a good bituminous compound is that it shall have a long life, shall not volatilize easily, shall stick to the pipe, and that when cold it shall have sufficient inherent strength to support the weight of the pipe, or, in other words, to maintain the grade. Pure asphalt for this reason is not suitable. It is not hard enough when cold and when being poured in water it is inclined to congeal and to float. To make it heavier, therefore, the jointing compounds consist generally of bitumen and a certain amount of inert material which increases the specific gravity and raises the melting point.

An important point is the life of such a joint, and this, of course, cannot be determined except through experience. It is a fact, however, that asphalt properly prepared and compounded for a street pavement, where the street is well drained, will last from 25 to 30 years without any great deterioration. An asphalt joint in a sewer pipe is protected by a jute gasket which keeps the acids in the sewage from coming in direct contact with it. It is also protected from outside water by the bell of the pipe, and hence, under average conditions, it would seem as if there can be but little question that the life would be from 25 to 30 years, and very possibly twice as much as that. A longer useful life than this cannot be predicted for any ordinary construction.

A further item in the cost of applying asphalt joints, at the present time, is the attitude of contractors generally. They do not like to work with it because they are unfamiliar with that character of work and they lack cost data on its use. It is believed that with experience the cost of making these joints can be very materially reduced.

Use of Asphalt Joints at Postville, Ia.—Asphalt used in combination with untarred dry jute as a jointing material was employed during 1915 in the construction of a system of sanitary sewers, comprising 4,875 ft. of 12-in., and 17,300 ft. of 8-in. tile pipe at Postville, Iowa.

The town of Postville is located on a swampy draw. The soil ranged through loam to blue clay. Ground water elevations were high, generally being within 2 or 3 ft. of the ground surface. Weather conditions during the construction period this past season were extreme, and a dry ditch was the exception rather than the rule. In the period from May 1 to September 1, out of 107 working days, it rained on 32. The successful employment of this material under such adverse conditions is an evidence of its practicability.

The jointing compound employed was "Filtite," Grade B, furnished by the Pacific Flush Tank Co. of Chicago, and selling F. O. B. Postville at $85 per ton. Dry jute for caulking cost $0.045 per pound.

Procedure in Construction.—In construction, 3-ft. lengths of sewer pipe were used (except Y's which were 2½ ft.) in order to cut down the number of joints and hence the expense. Y's for house connections were placed every 25 ft. on each side and sealed with tile discs, cemented in. One-half of the joints were poured on the bank by joining two lengths. The principal difficulty encountered at this stage of operations was in obtaining a good alignment. Cradles in which to pour the joint with the pipe in a horizontal position were first attempted, but the amount of time consumed and the results obtained did not warrant their further use. Later the double lengths were jointed by placing the two pipes together vertically, caulking the joint to the proper depth with dry jute and filling the remainder with the hot filler. The use of the 3-ft. lengths of sewer pipe is not altogether to be recommended as in that length the burning of the pipe causes a considerable percentage to be warped. Flat bells were numerous and these were employed entirely in the joint poured on the bank. Not only does a poor alignment result from the use of these warped pipes, since the bell and spigot are not at right angles to the axis of the pipe, but also in caulking the joint in the ditch it is difficult to get such a pipe "home" so that the jute will prevent the admission of the filler into the pipe.

After the joints had been poured on the bank and had cooled, the pipe was stored for use by laying on the ground and carefully blocking up the ends so that no strain came upon the poured joint. This precaution was found necessary since the temperature of the pipe lying in the direct rays of the sun was often high enough to soften the filler and permit a springing of the joint.

The ditch was prepared for pipe laying by digging bell holes as in the case of running a lead joint for cast iron water mains. A large bell hole is desirable for working conditions and also for intercepting ground water, while the joint is being poured. The bell of the pipe already in place was thoroughly cleaned of mud and water and dried with ravelled jute. Care taken in this preliminary results in fewer defective joints, though water, if clean, does not seem to obstruct the pouring of the joint. It is well to note here the item of expense for material for cleaning the bells of the pipe before jointing in the ditch. In this case ravelled jute was employed, but the cost is hard to estimate owing to the varying quantities used under varying conditions of the trench. Under extreme conditions this item amounted to 1 ct. per joint. Burlap sacking was tried with good results and low cost since this material could be used several times before discarding. Brushes of various kinds were tried but the results were not successful, owing to the difficulty in cleaning the brush.

The two lengths of jointed pipe were lowered into position in front of the bell already laid, by means of two slings on the pipe, a strand of jute placed under the invert of the spigot and the pipe shoved "home" securing the jute in the invert, and the caulking completed after aligning and grading the pipe. One strand of jute ½ in. in diameter and cut in length so as to lap 2 in. was ordinarily caulked into an 8-in. joint. In the 12-in. joint a single strand was affixed to the spigot of the pipe when shoved "home," and a second strand caulked in. An asbestos snake runner was then placed around the pipe and clamped on the top with the attached spring clamp, leaving a triangular opening into which the hot filler was poured. After being clamped in position tight to the bell the roll and bell were smeared with clay to prevent the leakage of the hot material. It was found best by experience to pour the joint from one side of the opening until the asphalt appeared at the top of that side, then to finish the joint from the other side. This procedure permitted the escape of the air enclosed by the runner and a better percentage of perfect joints resulted. A clay gate was added when the material had filled the triangular opening and an excess added in this gate to allow for the shrinkage in cooling. The joint was cooled by pouring water over the bell and roll where it was desirable to remove the roll as soon as possible. The runners were kept ready for use, immersed in water, to prevent the adherence of the asphalt.

When the roll was removed the joint was inspected and defects repaired if discovered present. An average of 5 per cent of the joints poured in the ditch required further attendance in the way of repairs. In water the tendency of the asphalt was to congeal before the bottom of the bell was filled. Repairs were made depending upon the location of the defect, as follows: Where a hole occurred in the invert and the top had been filled the runner was re-adjusted to the bell of the pipe, leaving a ½-in. space between the runner and the bell, as shown in the accompanying cut. A 4-in. belt of webbing, smeared with mud, was then passed around the pipe and buckled over the runner and bell. This provided a clear path for the hot asphalt, the web belt spanning and enclosing the space from the runner to the bell of the pipe. The belt was provided with two buckles at the top, leaving an opening 2 in. by 6 in. for the admission of the hot material. Enough asphalt was then added to fill completely the defect and to seal both sides. This method of repairing, though somewhat wasteful of material, was very effective and proved to be a time saver. The belt was made by the local harness maker at a cost of $1. When the defect occurred on the side of the pipe where easily accessible, the runner was re-adjusted as before and a pat of clay placed below and over the defect, covering bell and runner, leaving a gate at the top to pour into. For small holes in the joint this method was speedy and efficient.

Repairing Defective Joints.—Defective joints resulted more from the low temperature of the asphalt than from any other one cause. The presence of water in small amounts did not interfere when the compound was at the proper temperature. Too much emphasis cannot be laid upon the facilities for keeping the asphalt furnace close to the point where pipe laying is in progress. Other causes of defects were the presence of mud in the bell and pieces of foreign substances in the asphalt, through carelessness of the asphalt tender, also defective bells and spigots.

For pouring joints in the ditch a ladle holding approximately two quarts was used. The lip for pouring was placed at right angles to the handle. For pouring on the bank a pan 3½ in. deep and 9 in. in diameter having a 2-in. spout, was used. For tipping the pan when pouring a 3-in. holder was riveted into the side.

The labor involved in caulking and pouring the joints on the bank was as follows: For 8-in. pipe, one man could set up, clean spigots and bells and caulk and pour 100 ft. (33 joints) in one hour; for 12-in. pipe, two men working together could perform the same operations in 1 hour and 15 minutes. This is an average time. The variations were considerable, depending upon the amount of cleaning necessary before setting up the pipe.

The amount of dry jute required for an 8-in. joint was about 4 oz. when poured on the bank and 2 oz. where the joint was poured in the ditch, or an average of 3 oz. per joint. In the 12-in. joint 7 oz. were used in the joint poured on the bank and 4½ oz. when poured in the ditch, or an average of 5.75 oz. per joint. In other words, the jute was much better caulked on the bank than in the trench.

The furnace used for heating the asphalt was the ordinary type of sheet iron lead furnace. A cast iron kettle was fitted tightly to the opening by means of iron rings. The material was kept at a bubbling temperature so that the consistency was that of maple syrup. Some difficulty was at first encountered with the ignition of the asphalt. This was remedied by raising the smoke stack some 5 ft. above the kettle. When once ignited it was found best to empty out the burning liquid to prevent the formation of a hard clinker and the probable cracking of the cast iron kettle.

The importance of constant attendance to the asphalt kettle should not be under-estimated. Not only is the temperature of the material for pouring important, but also the constant stirring to maintain in suspension the inert filler used in this material. When not stirred the filler soon accumulates in the bottom of the kettle. The size of kettle used proved to be of too small capacity for the double duty of pouring joints on "top" and those in the ditch, when rapid progress was being made, but this is a good fault, as the volatilization of the asphalt is avoided. The addition of lumps of the cold asphalt lowered the temperature of liquid in the kettle unless a large quantity was present.

The asphalt tender reported for duty two hours before the work of pipe laying was commenced. At least 1 hour and 30 minutes was required to raise the temperature high enough so that the consistency was that of maple syrup.

No difficulty was experienced in keeping the pipe laying close behind a trenching machine in laying as high as 575 ft. of 8-in. pipe per day. The force consisted of an asphalt tender, two pipe tenders, a pipe layer and a bottom man, and in addition one man to pour joints after they had been caulked and the runner adjusted by the pipe layer. The additional man removed the runners and made repairs to the joints when found necessary.

In passing difficult places in the trench, such as broken drains where the joint to be run in the ditch happened to fall too close to the discharge of the drain to permit a successful joint, three lengths of pipe joined together on the bank were commonly employed.

As the labor, time and expense involved in damming and pumping large quantities of ground water is considerable, a cold asphaltic compound, which would be plastic for a few minutes and then harden up on exposure to air or water, would be a time saver and an efficient aid. Such a material is adapted for use where it is impossible to get the water in the trench below the pipe. While such compounds are on the market, the writer has had no experience with them.

Considerable difficulty was encountered in obtaining watertight manholes that were constructed of brick. In almost every case the inflow of ground water was sufficient to remove the green mortar from the lower courses of masonry. Repairs under these conditions were postponed until the inflow had diminished enough to render successful the application of a ½-in. plaster coat on the interior surface.

Tests for Infiltration.—Tests for infiltration made from time to time were entirely satisfactory. At no time during the construction of the system did the infiltration exceed 80 per cent of the 5,000 gal. per mile per day allowed by the specifications. This figure was reached after very heavy rains had raised the ground water level almost to the surface. Measurements of ground water infiltration were made at intervals, but no accurate estimate of the amount entering leaking manholes or those temporarily plugged for future laterals, could be made. Then, too, considerable ground water was permitted to enter the pipe at the point where pipe laying was in progress and the maximum rate was influenced by this cause.

No ground water discharge was observed at the outlet until 1,450 ft. of 12-in. tile had been laid, including four manholes. At that point an inverted siphon under a small creek, making a head of 2½ ft. on the joints, caused the first appearance of water at the outlet.

The specifications provided for tests for water-tightness as the work progressed from manhole to manhole. In construction it was found necessary to abandon this procedure for the following reasons: (1) It was intended to test for tightness as in water pipe tests, leaving the joints uncovered until the conclusion of the test. The ground water collected in the open trench to such a depth that the entire line of pipe floated off the grade and immediate backfilling became necessary. (2) Owing to the presence of large amounts of ground water it was necessary to keep an outlet from the point of pipe laying and blocking the outlet, for the time required for a test interfered seriously with the progress of pipe laying.

The method for testing the completed lines was planned as follows: After having sealed the lower end of the line at the manhole by means of a brick and cement plug, install an elbow and a 3-ft. length of pipe in the manhole at the upper end. Test by filling the line to a head of 4 ft. and measure the leakage by level observations to determine the rate of lowering in the riser. This method eliminated the manholes from the test and although results for the pipe only were desired, some test for manhole leakage is advisable.

Although no tests in this manner were carried to completion the following modifications were suggested from observations on an attempted test of a 12-in. line. The difficulties encountered in installing a 12-in. elbow and a 3-ft. length of pipe and pouring those connecting joints in any such limited quarters as a manhole suggested the use of a galvanized sheet iron elbow and riser of 6 or 8 in. in diameter fastened to a plug of the diameter of the pipe to be tested. This plug could then be caulked tightly into the pipe to be tested. To eliminate the time necessary for the construction, setting and subsequent removal of a masonry plug in the down stream end a wooden plug fitted with a gasket and caulked tight is suggested.

The results of the tests at Postville are shown in Tables I and II, which are sufficiently clear in themselves. The variations in the per cent of allowed discharge in Table I and in the infiltration per inch of joint per 24 hours in Table II are only what might be expected from tests made at the time of construction, since a large amount of ditch was constantly open, construction going on at the upper end, and hence a considerable amount of ground water coming from these sources. In spite of that it will be seen that the infiltration was considerably less than that allowed by the specifications. The conditions at Postville were very extreme, practically all the time there was a head of from 2 to 4 ft. on the sewers.

TABLE I—VARIATIONS IN PER CENT OF ALLOWED DISCHARGE IN PIPE SEWERS WITH ASPHALT JOINTS, POSTVILLE, IA.

Report.	Total lin. ft. laid.	Lin. ft. of 12-in.	Lin. ft. of 8-in.	Allowed discharge. Gal. per 24 hr.	Measured discharge. Gal. per 24 hr.	Per cent of allowed discharge.
61	4,483	4,185	300	4,245	2,160	50.9
95	7,946	4,488	3,458	7,525	5,930	78.8
120	11,415	4,488	6,927	10,865	6,048	55.6
146	15,585	4,875	10,710	14,755	10,080	68.3

TABLE II.—INFILTRATION INTO CLAY PIPE SEWERS WITH ASPHALT JOINTS, POSTVILLE, IA.

Report.	Approx. number 12-in. joints.	Approx. number 8-in. joints.	Total lineal inches of joint.	Measured discharge. Gal. per 24 hr.	Infiltration per inch of joint per 24 hr.
61	1,445	104	63,178	2,160	.0342 gal.
95	1,545	1,191	96,381	5,930	.0614 gal.
120	1,545	2,386	128,287	6,048	.0471 gal.
146	1,675	3,689	168,502	10,080	.0598 gal.

TABLE III.—COST OF ASPHALT JOINTS IN CLAY PIPE SEWERS.

		Cost per joint.	Per foot.
		8-in.	
8-in. pipe	Jute, 3 oz.	$0.009	
3-ft. lengths	Asphalt filler	.085	
	Labor	.01	
		$0.101	$0.035
		12-in.	
12-in. pipe	Jute, 6 oz.	$0.016	
3-ft. lengths	Asphalt filler	.128	
	Labor	.025	
		$0.169	$0.0544

Labor, 25 ct. per hour.
Joint compound, $85 per ton.
Jute, 4½ ct. per lb.

The cost of the joints as observed at Postville are as shown by Table III. This is an average cost for both pouring joints on the bank and in the ditch. Other items may enter into the cost of pouring in the ditch and tend to increase it, but such item would be local and the table simply shows what the cost should be under average conditions in which men and materials are at hand and the work is fairly economically done. One of the points observed was that the joint compound did not tend to adhere to the glazed surface. The spigot end of sewer pipes are generally unglazed, though occasionally the glazing extends clear up to the end. Where this glazing so extended it was very difficult to get a good joint. Another point to be observed is that it would be well always to specify "deep and wide socket pipe." One of the difficulties in getting a good joint using standard pipe is the narrowness of the annular space. This accounted for a large percentage of defective joints, and such percentage would be very much reduced by the use of deep and wide pipe. A further improvement as regards the life of a joint would probably be made by the use of tarred jute. The handicap in using tarred jute is that the oil gets on the pipe and when there is such an oil it prevents the bituminous compound from adhering to the surface, thus providing a poor joint. It is believed, however, that this defect could be overcome by good workmanship, and that the life of the joint would be increased by the use of this tarred jute.

The system was constructed, under contract, by M. Tschirgi & Sons of Cedar Rapids, Iowa. Marr, Green & Co. of Chicago were the Engineers, and Mr. G. L. Opper, C. E., was their resident engineer. Mr. Opper made all the observations and tests described in this article.

COSTS IN ILLINOIS OF CONCRETE ROAD MAINTENANCE USING PORTABLE HEATING KETTLE AND AUTO TRUCK.*

Only cost data in maintaining the slab or pavement proper are given. It will be noted from Table I that the average cost of maintenance where the truck was used is about one-third less than where the portable hand kettle was used. This will be offset considerably more in favor of the truck when the cost of supervision is recorded and the time required for doing the work is taken into consideration. The division engineer must necessarily give considerable of his time to maintenance work, where the portable hand kettle is used. However, he has the opportunity to select good weather for all work done with the outfit and accordingly does not have any men charged against maintenance work when they are not able to work on the roads, as has been the case with the truck.

It will be noted from the table that the cost of filling cracks and joints varies from $0.0010 to $0.0057 per square yard of pavement, the cost usually varying in proportion to the discontinuity of the pavement. Discontinuity is represented by the figure found by dividing the total length of all cracks and joints, in feet, by the square yards of pavement. The expression of discontinuity is figured for each road on which work is done, as it serves as a guide to compare the cost of maintenance work. It also gives a basis for comparing the condition of surfaces on various pavements.

The specifications under which the state aid roads were constructed required a ¼-in. felt joint to be placed at an angle of 75 degrees with the center line of the pavement and at intervals of 100 ft.; joints were also required at the close of each day's work, but in no case were they to be spaced less than 40 ft. unless specified by the engineer. The 10 and 18-ft. pavements, when constructed under these specifications, have, under normal conditions, a discontinuity of from .090 to .100. If joints had been placed at 50-ft. intervals instead of 100-ft. the discontinuity of the surface on the normal 10 and 18-ft. pavements would have been from .180 to .200. From a maintenance standpoint, therefore, it would be an advantage to have as few joints as possible. Four years' experience in maintaining concrete pavements in Illinois indicates that joints, even though protected with armor plates, require about the same attention as do the ordinary cracks.

TABLE I.—COST DATA SHOWING THE RELATIVE EFFICIENCY OF DIFFERENT METHODS OF MAINTAINING CONCRETE PAVEMENTS BY FILLING CRACKS AND JOINTS WITH BITUMINOUS MATERIAL.

PORTABLE HEATING KETTLE USED.

	Conditions						Cost of labor			Materials					
County.	Section.	Built.	Width	Sq. yd. (a).	Total length in ft. of cracks and joints (b).	Expression of discontinuity of pavement (b/a).	Skilled.	Common.	Teams, freight, storage, transportation.	Bituminous material.	Sand and stone	*Dep. on equipment.	†Supervision.	Total cost.	Cost per sq. yd
Cass	A	1914	10	7,279	917	.126	$11.00	$ 3.50	$ 9.96	$ 1.92	$0.60	$1.25	.....	$28.23	$0.0039
Iroquois	A	1914	10	13,433	1,753	.130	3.90	4.80	8.85	5.17	.40	2.30	.....	25.42	.0019
Iroquois	B	1914	10	14,784	1,980	.134	3.30	4.40	10.60	4.63	.42	2.60	.....	25.95	.0017
Sangamon	..	1912	18	12,600	6,065	.472	10.00	17.67	11.25	20.87	2.00	1.21	.....	63.00	.0050
Sangamon	B	1914	18	4,400	854	.194	5.00	7.30	8.75	3.75	....	.40	.....	25.20	.0057
Sangamon	C	1914	18	4,400	577	.131	3.00	1.22	1.25	1.87	.20	.40	.....	7.94	.0018
Sangamon	D	1914	18	4,000	774	.193	3.00	1.22	1.25	1.87	.20	.40	.....	7.94	.0020
Sangamon	E	1914	18	4,700	690	.147	5.00	4.12	3.75	1.87	.30	.45	.....	15.49	.0033
Menard	A	1914	10	2,667	290	.108	3.85	.70	3.61	1.25	.25	.45	.....	10.11	.0038
Average cost per square yard															$0.0032
AUTO TRUCK USED.															
Logan	A	1914	10	4,000	458	.115	$ 3.00	$ 2.00	$ 0.56	$ 1.74	$0.10	$1.40	.....	$ 8.80	$0.0022
Logan	D	1914	10	4,000	503	.126	3.00	2.00	.70	2.17	.10	1.40	.....	9.37	.0034
Livingston	A	1914	10	13,810	2,240	.162	12.00	3.75	2.80	5.57	.50	4.70	.....	29.32	.0021
Kankakee	A	1914	10	10,500	1,711	.163	14.00	4.00	1.30	5.30	1.00	3.60	.....	29.20	.0028
Will	A	1914	10	10,666	2,000	.188	18.00	4.60	4.89	4.62	.20	3.60	.....	35.91	.0034
Cook	E	1914	18	38,884	5,488	.141	21.00	8.00	4.54	8.92	.40	7.40	.....	50.86	.0013
Cook	B	1914	18	14,222	1,821	.128	4.50	3.00	1.26	5.72	.10	2.75	.....	17.33	.0012
Cook	A	1914	18	5,246	706	.135	1.50	1.00	.57	1.11	....	1.00	.....	5.18	.0010
Average cost per square yard															$0.0022

*Under depreciation one dollar per mile of pavement maintained is charged against the portable heating kettle equipment and two dollars per mile for the auto truck.

†The cost of supervision is prorated against the maintenance and upkeep at the close of the season.

ERECTION PROGRESS ON THE QUEBEC BRIDGE.*

By H. P. Borden, Assistant to Chief Engineer, Quebec Bridge.

When work on the Quebec Bridge closed down a year ago the north anchor arm was completed out to the main pier with the exception of two panels of the upper web members and top chord. On the south side no steel at all had been erected between the main and anchor piers.

Erection of Main Posts.—About the middle of April a start was again made on the erection of the steel on the north shore, and on May 3, 1915, the erection of the main posts was begun. These posts rest on the shoes over the main pier and are the largest single members in the bridge, being 310 ft. high, center to center of pins, and approximately 10 ft. square. As the four posts required for the bridge weigh approximately 6,000 tons and cost about $1,000,000, or considerably more than the entire cost of many important bridges, some idea of the magnitude of these members may be obtained. Each of these members is composed of four separate columns latticed together in four directions and terminated by a tapered solid section at both top and bottom. To facilitate shipment and handling, each of these members was shipped in 26 separate sections and spliced together in the field. It was expected that serious difficulty might be encountered in the erection of these sections as they had to be put in place with splice plates attached to the ends and lowered with extreme precision, to allow the webs and flanges of the adjoining section to be entered between the various plates and angles forming the splice. The efficiency of the electrically controlled hoists on the erection traveler, however, was such that this work was carried out with remarkable rapidity, both posts on the north side being erected and sufficiently riveted to allow the traveler to be moved ahead within one month from the time a start was made. Sufficient riveting was done on these members to take care of all erection stresses before any further steel was erected or the traveler moved ahead. This riveting was considered highly advisable rather than filling the holes with bolts and drift pins and riveting later as the work progressed, as it was found from past experience that once a strain was applied to a drifted joint it was absolutely impossible to remove these drifts except by drilling. The cramped space in the interior of these members also made riveting somewhat difficult, but with the use of specially designed jam riveters, which could work in a space down to 14 in., very satisfactory work was obtained. While in some cases the heads of inside rivets were not perfect, yet, in all cases, tight rivets were obtained.

---

*Extract from report of committee to the Second National Conference on Concrete Road Building.

*From paper in The Contract Record.

Erection of Cantilever Arm.—When the erection of the main post had proceeded to the desired stage, the traveler was moved ahead and the erection of the first panel of the cantilever arm was started. As the bottom chords have a field splice between main panel points it was necessary to devise some support for these members for riveting this splice before it could be connected to the main panel point. This was accomplished by means of a "flying bridge," or heavy steel platform, extending for one full panel length and for the width of the bridge. On this flying bridge, which was supported by links to the structure above, the bottom chords were assembled and jacked up into their proper alignment, and the center splices fully riveted up. As each panel was completed the flying bridge was moved ahead to the next panel. This work went ahead very rapidly, as all field splices and connections had previously been reamed out in place at the shop, thus avoiding any shop errors or the necessity of making any alterations or changes in the field. As each panel was erected, accurate measurements were taken to see that the alignment was correct. Owing to the extreme accuracy with which this work was manufactured and inspected in the shop, no difficulty of this nature was encountered, the alignment of both the anchor and cantilever arms throughout their entire length being absolutely correct.

Members on both sides of the bridge were erected simultaneously by the traveling cranes and stiff-leg booms, and as the traveler moved ahead the sway bracing was put in position by the rear booms. Practically all splices in web members were riveted up complete before moving ahead, or at least sufficiently riveted to carry the full erection stress. Remarkably good records were made in riveting, the percentage of rivets to be cut out being very low. In one case over 4,000 rivets were driven in the splices of the bottom chords, and only one loose rivet was found by the inspectors. This extraordinary record was due, naturally, to the experienced riveters employed on the work, and also to the fact that in reaming out the splices in the shop from 25 to 50 per cent of bolts were used in bolting up the splice material, thus preventing drillings getting in between the web plates of the member. When the splice was taken apart care was taken to clean out all drillings that might be found to exist between any parts of the splice material.

By the middle of November the cantilever arm was completely erected, being quite up to the progress laid out by the bridge company at the beginning of the season. The work of the traveler having been completed on this side of the river, it is now being taken down and will be re-erected at the site where the suspended span will be erected next year. On the south shore the erection of the falsework to support the anchor arm was started about the middle of April, this falsework being taken from the north shore where it had been used to support the north anchor arm.

Erection of Anchor Arm.—The erection of the anchor arm was started on July 7, and, owing to the experience gained on the north side, it was erected much more rapidly, a gain of over six weeks being made in the completion of this work. By the middle of November the entire anchor arm had been erected, including the main posts, with the exception of a certain amount of riveting which will be completed next year.

Summary.—During the past season about 30,000 tons of steel were erected. In all, about 45,000 tons have been erected out of a total of 65,000 tons—the estimated weight of the steelwork in the bridge. The record day's tonnage in 1915 was 670 for the south shore traveler, although there were several days in which over 600 tons were erected by this traveler. An average of 350 tons per day was made in the erection of the south main post.

Next season the south cantilever arm will be erected, and it is expected that this work will be finished early in September. The suspended span will also be erected at Sillery Cove, a point some three miles below the bridge site. When completed it will be floated to the site on six pontoons, 160 ft. long and 32 ft. wide, each having a working draft of 8 ft. This span, which is 640 ft. long, 110 ft. high at the center, 88 ft. wide, and weighs about 5,000 tons, will then be attached to long hangers from the ends of the cantilever arms and jacked into place by means of heavy jacks placed on the erection girders at each corner of the cantilever arm. This operation should not take over 24 hours if everything works smoothly. By the end of 1915 practically all the steelwork of this bridge should be in place, and it will be possible for working trains to cross the river at this point.

Personnel.—The erection is under the supervision of the Board of Engineers, Quebec Bridge, C. N. Monsarrat, chairman and chief engineer, and Ralph Modjeski. (The late C. C. Schneider was also a member of the Board.) The contract is being carried out by the St. Lawrence Bridge Co., Ltd., of which Geo. F. Porter is engineer of construction, W. B. Fortune, superintendent, and S. P. Mitchell, consulting engineer of erection.

CAUSES OF RECENT BREAKS IN SEATTLE WOODEN STAVE WATER SUPPLY PIPE LINE.

The public water supply of Seattle is conveyed from the Cedar River to the city by two wooden stave pipe lines, known locally as Cedar River Pipe Lines Nos. 1 and 2. The former has been in service since Jan. 10, 1901, and the latter since June 21, 1909. Early in January this year breaks occurred in No. 2 which cut off part of the city's water supply. Mr. R. H. Ober, Consulting Engineer, Seattle, a former city official, was engaged to make an investigation and report on the cause of the failures. The following information is from his report.

The first leak appeared at Grouse Ridge, about four miles from the intake at Landsburg; the second at a point near Rock Creek, about 2½ miles below the intake; the third near the station of Noble, on the main line of the Chicago, Milwaukee & St. Paul Railroad, at a point about two miles below the intake; and the fourth in the vicinity of Molasses Creek, which is between Swan Lake and Renton and about eleven miles from the intake. All of these leaks occurred in the immediate vicinity of standpipes located at summits in the pipe lines.

The first and fourth leaks were of a comparatively minor nature, involving a relatively small amount of work in the replacement of one or more staves which were not decayed, but which were defective when originally built into the pipe. The second and third leaks, however, were of a very serious nature, involving material injury to the pipe line and reconstruction in each case of a considerable length of pipe. The water contained in the standpipes in the vicinity of the second, third and fourth leaks had been frozen, and the standpipes had thereby been rendered incapable of performing their proper functions. The freezing of these standpipes made it impossible for air to enter the pipe lines to take the place of the water that was drawn off in cleaning the settling basin at Landsburg and in repairing the first leak at Grouse Ridge. This resulted in the formation of a vacuum in the vicinity of each of these standpipes and the consequent collapse of the pipe by reason of the unbalanced atmospheric pressure upon the outside of the pipe.

With the repair of the first leak at Grouse Ridge and the subsequent admission of water to the pipe line the escape of the water from the broken pipe in the vicinity of Rock Creek became noticeable and resulted in the washing out of the hillside at that point before the water was shut off at the intake.

With the repair of this section of the pipe and the subsequent admission of water into the pipe line, the damaged condition of the collapsed pipe at the third leak, in the vicinity of Noble, became noticeable through the escape of the water and the washing out at the hillside at that point. Subsequent to the reconstruction of the collapsed pipe at the third break, near Noble, the fourth break, in the vicinity of Molasses Creek, was discovered and repairs were made at this point. It is found that the wood staves of which pipe line No. 2 is constructed, which have been in service for a period of about seven years, are in very good condition, as shown by those exposed to view and by those removed from the broken sections. The outer surface of the wood, generally speaking, shows scarcely any signs of decay; where decay is to be seen, it is relatively small in amount and extends to a depth not exceeding 3/16 in. at any point observed.

Cause of Breaks.—It is believed that the injury to the pipe was not occasioned by the decay of the wood staves of which the pipe is constructed, nor by reason of the fact that the pipe was constructed of wood instead of some other material. The formation of a vacuum as a result of the freezing of the standpipes would have caused the collapse of a steel pipe or of a reinforced concrete pipe as surely as of the wood stave pipe, and the repairs that would have been necessary in the case of the steel or reinforced concrete pipe would have required a much longer time and larger expense than in the case of the wood stave pipe.

It is believed that the injury to the pipe lines and the consequent interruption of the water supply of Seattle were due to lack of care in the construction of the standpipes and to failure to prevent the water in these standpipes from freezing.

The construction of the standpipes was defective by reason of the fact that the pipes were very much smaller than should have been installed, being, in fact, in some cases about one-seventh of the area which should be provided in order to afford reasonable protection against accidents of this kind. Lack of care was shown by the failure to protect the pipes in such a manner that there would be no possibility of the freezing of the water contained therein.

The fact that the water in those standpipes was frozen should have been discovered by the person or persons charged with the responsibility of protecting the water supply of Seattle and should have been discovered in time to permit thawing out the standpipes before shutting off the water in the pipe lines. After the damage had occurred, it was evidently discovered that the water in these standpipes was frozen, and efforts were made to thaw out the pipes by means of building fires on the ground around them and by the use of oil applied to the standpipe within the outer casing. These fires at several standpipes destroyed what protection had been afforded by means of wooden boxes inclosing the standpipes, which boxes were filled with sawdust. The destruction of these boxes left the standpipes exposed to the weather and in a worse condition than existed before the occurrence of the breaks in the pipe lines, and they were allowed to remain in this exposed condition after the repairs to the pipe line had been completed, thus exposing the city to the danger of a further collapse of these pipes and the consequent interruption to the water supply.

RATLER TEST FOR PAVING BRICK.*

The machine shall be of good mechanical construction, self-contained, shall conform to the following details of material and dimensions, and shall consist of barrel, frame, and driving mechanisms as herein described.

The barrel of the machine shall be made up of the heads, headliners, staves, and stave-liners.

The barrel shall be mounted on a cast-iron frame of sufficient strength and rigidity to support it without undue vibration. It shall rest on a rigid foundation with or without the interposition of wooden plates, and shall be fastened thereto by bolts at not less than four points. It shall be driven by gearing having a ratio of driver to driven of not less than one to four.

The abrasive charge shall consist of cast-iron spheres of two sizes. When new, the larger spheres shall be 9.52 cm. (3.75 in.) in diameter and shall weigh approximately 3.40 kg. (7.5 lb.) each. Ten spheres of this size shall be used. These shall be weighed separately after each ten tests, and if the weight of any large sphere falls to 3.175 kg. (7 lb.), it shall be discarded and a new one substituted; provided, however, that all of the large spheres shall not be discarded and substituted by new ones at any single time, and that so far as possible the large spheres shall compose a graduated series in various stages of wear. When new, the smaller spheres shall be 4.762 cm. (1.875 in.) in diameter and shall weigh approximately 0.43 kg. (0.95 lb.) each. In general, the number of small spheres in a charge shall not fall below 245 nor exceed 260. The collective weight of the large and small spheres shall be as nearly 136 kg. (300 lb.) as possible. No small sphere shall be retained in use after it has been worn down so that it will pass a circular hole 4.45 cm. (1.75 in.) in diameter, drilled in an iron plate 0.64 cm. (¼ in.) in thickness, or weigh less than 0.34 kg. (0.75 lb.). Further, the small spheres shall be tested, by passing them over the above plate or by weighing, after ten tests, and any which pass through or fall below the specified weight, shall be replaced by new spheres; provided, further, that all the small spheres shall not be rejected and replaced by new ones at any one time, and that, so far as possible, the small spheres shall compose a graduated series in various stages of wear. At any time that any sphere is found to be broken or defective, it shall at once be replaced.

The iron composing these spheres shall have a chemical composition within the following limits:

Combined carbon	Not less than 2.50 per cent.
Graphitic carbon	Not more than 0.25 per cent.
Silicon	Not more than 1.00 per cent.
Manganese	Not more than 0.50 per cent.
Phosphorus	Not more than 0.25 per cent.
Sulphur	Not more than 0.08 per cent.

The number of bricks per test shall be ten for all bricks of so-called "block-size," having dimensions which fall between 20.32 and 22.86 cm. (8 and 9 in.) in length, 7.62 and 9.52 cm. (3 and 3¾ in.) in breadth, and 9.52 and 10.8 cm. (3¾ and 4¼ in.) in thickness. No brick should be selected as part of a regular test that would be rejected by any other requirements of the specifications under which the purchase is made. (Note by Committee.—Each brick should be marked by small holes drilled in one of the faces of the brick, and the initial weight of each brick composing the charge should be determined.)

The rattler shall be rotated at a uniform rate of not less than 29.5 nor more than 30.5 rev. per min., and 1,800 revolutions shall constitute the test. A counting machine shall be attached to the rattler for recording the revolutions. A margin of not more than 10 revolutions will be allowed for stopping. Only one start and stop per test is generally acceptable. If, from accidental causes, the rattler is stopped and started more than once during a test, and the loss exceeds the maximum permissible under the specifications, the test shall be discarded and another made.

The scales must have a capacity of not less than 136 kg. (300 lb.), must be sensitive to 14.17 grammes (0.5 oz.), and must be tested by a standard test weight at intervals of not less than every ten tests.

The loss shall be calculated in percentage of the initial weight of the brick composing the charge. In weighing the rattled brick, any piece weighing less than 0.45 kg. (1 lb.) shall be rejected. (Note by Committee.—The loss for each brick should also be calculated in percentage of the initial weight of each brick composing the charge.)

---

*Proposed by the National Paving Brick Manufacturers' Association and adapted from the "Standard Specifications for Paving Brick," adopted in 1915 by the Am. Soc. for Testing Materials.

Engineering and Contracting

Devoted to the Economics of Civil Engineering Design
and to Methods and Cost of Construction

EDITORS
H. P. Gillette C. S. Hill C. T. Murray S. C. Hadden C. W. Malcolm

Volume XLV. CHICAGO, ILL., MARCH 1, 1916. Number 9.

IRRIGATION ENGINEERING AND PRACTICE.

The problem in irrigation during 1916 as it was during the preceding year is how to get irrigated land taken up and irrigation projects placed on a paying basis. Until this problem is solved no great development of new irrigation construction is probable. In the year now just begun, however, will come, we think, the preparatory work just indicated which brings nearer a resumption of new construction. The possibilities of irrigation farming are too great to permit of a moribund condition of long duration in irrigation works development.

It has been charged against the irrigation engineer that he has given too little thought to irrigation works as a plant for producing merchandise having a market. Instead he has designed and constructed them as if the structures and their permanence were the end in themselves. Doubtless these accusations have been exaggerated, but exaggeration is possible only when some basis of truth exists, and such a basis of truth does undoubtedly exist in irrigation engineering practice as it is recorded by many irrigation works of the last decade. Engineers who plan and build irrigation works are on this account in duty bound to make an appraisal of their methods and to modify them against the time when new construction will demand their services.

It is with the thought just exemplified in mind, that we have undertaken the publication during the coming months of 1916 of a series of articles on irrigation engineering and practice. The first of these articles on Classification of Expenditures for Irrigation Work is published in this issue. Another will follow on the Economic Comparison of Concrete and Wood for Irrigation Structures. A third will discuss the Flow of Irrigation Water Over Soils in Different Methods of Application. A fourth will describe methods of Accounting and Business Procedure as Applied to the Construction of Large Irrigation Works. Titles of other articles are not yet definitely determined but will be announced from time to time as selection is made. We direct the attention of our irrigation engineer readers to this series in the belief that they will find the articles to be of a kind and quality not commonly published. Incidentally the authors of these articles are practically experienced in the problems which they discuss.

A CORRESPONDENCE COURSE ON ROAD BUILDING.

Announcement of and a series of lesson sheets for a correspondence course on road construction have been received from Professor James I. Tucker of the University of Oklahoma. Our information is not complete in university extension matters but we imagine that this is for the road builder the first course of its kind to be inaugurated by a State university. For the modest sum of $9 the Oklahoma institution gives a series of 24 lessons on road building. There are now enrolled 30 students, and the undertaking is scarcely two months old. All of these students are residents of Oklahoma but the course is not limited to state residents—anyone anywhere who desires the course can receive it on exactly the same terms. Incidentally the Oklahoma Department of Highways in its examinations allows substantial credit to holders of certificates of completion of the University correspondence course.

There is much that interests engineers in the undertaking of Professor Tucker. For a number of years our State Universities in considerable numbers have presented short winter courses in highway engineering. Commendation of these courses has been a pleasure to the editors of this journal. They have, however, a common fault. Time enough is not had in two or even three weeks by those most needing instruction to assimilate the condensed information handed to them. A merit, in comparison, of the correspondence course is that it gives this time. Neither course will turn out a trained road engineer, but the correspondence course is the more likely to approach this result closely. This assertion of course is based on opinion merely; there has been no accumulation of experience from which to reason. From a careful reading of the Oklahoma lesson sheets, we are certain of one thing and it is that any man who passes a searching examination on them, whether or not we call him an engineer, will be a mighty good hand to have in immediate direction of road construction and maintenance.

THE DESIGN OF CONCRETE FORMS.

It has required several failures of reinforced concrete structures during construction to impress upon some engineers and builders the fact that the application of engineering knowledge and skill to the design of concrete forms is of prime importance. Until quite recently the layout and design of forms, as well as their actual construction, were entrusted to ordinary carpenters, and this practice is still continued by many builders. A number of engineers and contractors specializing in concrete construction have, however, recognized the importance of form design and are applying to this part of the work the same knowledge and skill as is directed toward other construction operations. In such cases the natural result has been a great reduction in the cost of the forms, together with the use of a definite factor of safety in every unit of the form design.

In this issue we are publishing Part I of a comprehensive article treating of the planning and designing of concrete forms—an article which presents the subject in a definite and practical manner. Advances in form design have not kept pace with advances in our knowledge of the principles of reinforced concrete design and with construction equipment, and there is present need for definite information on systems of form design and construction which have proved their worth in practice.

A DECADE OF CONSTRUCTIVE CRITICISM.

A few weeks ago this journal very quietly celebrated its tenth birthday anniversary. The end of our first ten years was also the end of the first decade of constructive criticism of the practice of civil engineering in this country. This didn't just happen so. This journal and the character of criticism of which we write are twins. With its first issues Engineering and Contracting began to preach the doctrines of engineering economics, of cost keeping and management engineering, of broader public interests and responsibilities by and for the engineer, etc. At first these doctrines were considered heretical and in many quarters were received with disapproval, ridicule, or indifference. Now they are so well established that they seem always to have been with us.

About five years ago a mature engineer said he had not read an engineering journal for several years. He said engineers had a provincial viewpoint and were sophomoric and that the engineering paper was their Boswell. He said the complacent thought, "What wonderful fellows we engineers are!" stood out boldly on every page of an engineering paper. Then we told him of the work of constructive criticism which had been going on for a few years and he was greatly impressed. A little later we began to notice signed contributions by him in several of the engineering journals. His conversion was complete and permanent. Very likely he sees the changed attitude of the engineering journal which is: "What wonderful fellows we engineers are in a fair way to become."

Flattery is foreign to modern editorial policy. It is incompatible with the genuine respect in which the editor holds the engineer. This is the era of constructive criticism and it works both ways. Many improvements in technical journals have followed the kindly criticisms offered by practicing engineers. Much enlightenment has come to us from the outside, and it continues to come. For this we are thankful. On the other hand, we believe that a large and rapidly increasing number of engineers appreciate that in their pilgrimage to the promised land the engineering journal has been "a light unto their feet and a lamp unto their pathway."

UNIFORM AND DEFINITE LUMBER SPECIFICATIONS.

A great loss has been sustained by lumber interests and by builders during the past few years, due partly to the lack of definite and uniform specifications for the various kinds of lumber and in part to the fact the average user of lumber is unable to determine definitely the quality of lumber available. In most cases architects and engineers have drawn up their own specifications from whatever information was available, and the result has been that great difficulty has often been experienced in obtaining satisfactory lumber at a reasonable price.

At a recent meeting of the Illinois Society of Architects, also attended by a large number of lumber representatives, the advisability of formulating standard architectural specifications governing all classes of lumber and timber was acknowledged by all, and steps were taken which seem to assure definite progress toward this end. The Southern Pine Association and the Chicago Lumber Association volunteered to co-operate with the Illinois Society of Architects in drawing up standard specifications, and their offer was accepted by the latter society and a committee appointed to take up the work. Lumber is an exceedingly important building material for many types of structures, and this recent action of producers and consumers will undoubtedly prove of great benefit to both.

WARNINGS THAT WATER SUPPLY IS CONTAMINATED ARE LARGELY DISREGARDED.

It is generally asserted that the first duty of those who furnish water to the public is to see to it that the supply is at all times pure. If, for any cause, the supply becomes contaminated, it is the custom to go through the motions of notifying the consumers to this effect. Sometimes warnings to boil the water are published in the newspapers. Frequently such published notices are supplemented with bills posted in conspicuous places and, occasionally, with hand-bill announcements of the fact which are delivered directly to the consumer. That such announcements are better than nothing at all is admitted but it must not be supposed that they are regarded seriously by all who use the water supply. In fact such warnings are disregarded by many people—perhaps by the majority.

In one case where a water supply suddenly became contaminated, due to cataclysmic circumstances, hand-bills setting forth that fact, and warning people to boil their drinking water, were delivered to all consumers. After the supply was brought back to its normal state of purity a canvass was made to see how many people had boiled their drinking water. It was found that 67 per cent of the water consumers had utterly disregarded the warning! This was in a large, enlightened, and progressive community.

Another interesting case occurred in an Illinois Chautauqua encampment last summer. The water supply, derived from three shallow, dug wells, became contaminated. This fact was known and signs were posted at various points on the grounds warning people not to drink the water. The warning was disregarded—many people asserted that they wanted a drink and were willing to take a chance on the purity of the water. A typhoid epidemic leading to nearly 200 cases and 13 deaths was the result.

People, generally, will drink a water that looks all right, no matter what the evidence of contamination. A thirsty man will have his drink, if he can get it, though he die from it. This emphasizes anew the imperative duty of providing a pure supply. The evils arising from an impure supply cannot be corrected by notices to boil the water.

EXPRESS YOUR VIEWS.

In travelling around the country the editor meets many engineers who have given much thought to some subject to which other men have not turned their attention. Whether it is true or not, as has been asserted, that there is one good novel wrapped up in every man's intellect, we are confident that there is at least one first class editorial in every engineer's system and it is our purpose to assist in its elaboration.

The editors are always pleased to receive for publication letters bearing upon topics of interest to the readers of this journal. We are especially grateful to the men who write about the little things; about the details of the daily work of the engineer and the contractor. There is something of a temptation to tackle the big problems, we know for every once in a while we catch ourselves launching some sort of wonder-working reform, so it is a great comfort to get letters from men who merely seek to improve engineering practice in one small particular.

Letters having to do with matters of daily application are, therefore, always welcome to the editors. Correspondents should bear in mind that what is old to one man is new to another. What has helped you will help many others. What have you found out in your practice of engineering which interests or has helped you greatly? What is that one subject about which you have been thinking for five or ten years or longer, and what have you thought about it?

Being thus encouraged perhaps you will write to the editors. However great the inclination to imitate the modest violet beside the mossy stone, remember that attitude is rather more poetical than businesslike. We specifically refrain from any reference to the folly of keeping one's light under a bushel.

EDITORIAL COMMENTS.

Is a professor of engineering in responsible charge of engineering work or is he merely engaged in active practice? The Committee on Proposed Revision of the Constitution of the American Society of Civil Engineers wants opinions on this question. Strictly speaking, it wants only opinions from "corporate members" of the Society and so having our rights as free Americans thus challenged we are not diffident about saying that any man who carries some scores of high blooded youth of mixed parentage through four years of engineering instruction without exceeding the allotted percentage of "flunked" men has responsible charge of a rather exacting engineering task.

Also the Revision Committee wants to know whether the Society shall lay the accolade and bestow its shield upon woman civil engineers. On this question we shall leave expression of opinion entirely to "corporate members."

In six months the Highway Department of Oklahoma has collected $154,198 in automobile taxes; examined 80 county engineers; passed on plans for 250 bridges and 50 culverts; examined and approved profiles for 200 miles of roads; issued five circulars and seven forms, contracts and specifications, and, in spare time, held conferences with county road officials. At that the employes of the Department worked only "from 12 to 15 hours per day." During its second six months the force expects to get down to real work. Incidentally the total annual salary roll of the Department is $7,000.

And withal the Department has kept its poise beautifully as witness the following excerpt from its half-yearly report:

> Reports show that the average cost of preliminary surveys and plans for state roads in 46 counties, where such work has been, is $10.05 per mile. In eight of the 46 counties such cost exceeded $20 per mile, and the remaining 38 counties averaged $6.70 per mile. On account of the fact that the engineering feature is something to which the County Commissioners and the general public are not accustomed in Oklahoma, there has been some complaint about this expenditure, but it is thought on further consideration, when the County Commissioners realize that such preliminary engineering work need be done but once, as a rule and is not construed as an annual expense in the future, they will be better satisfied that the public has derived a benefit commensurate with the amount expended for engineering.

Tire expense is the bete noir of the motor vehicle owner. And among our other troubles intensified by the European war comes the news that rubber prices, which have been soaring for two years, are due for a higher flight. To counteract the increase there comes from the tire makers an urgent plea that sizes of motor car wheels be standardized and reduced in number. "By simplified manufacturing processes," say the tire makers, "tire costs are bound to decrease in proportion as fewer molds and less special tire building machinery are required." This sounds entirely logical. To the engineer and contractor user of motor vehicles, on the other hand, a dozen, say, diameters of wheels appears wholly illogical.

In enumerating the various methods of garbage disposal it is customary to include feeding to swine. Why swine? If there is any virtue in calling a spade a spade, as many plain Americans stoutly maintain, why not call a hog by his right name?

The moral of one of George Ade's delightful fables is: "Give the people what they think they want." That is good business policy. It is also first class political doctrine, as even our state lawmakers know. People must tell their representatives what they want. There is more than one way to do this but the most effective way is by word of mouth. An active, vocal delegation in a committee room of a state capitol exerts more influence on legislation oftentimes, than the published opinions of all the newspapers of the state, and more than a truck load of letters. Engineers interested in fostering legislation favorable to their calling might do worse than reflect on this point.

There has been a lot of loose thinking and talking about pork barrel legislation. Every pork barrel Congressman has a pork barrel constituency which expects him to "bring home the bacon." In the Illinois Legislature there is a member who heads the alliance between corrupt business and corrupt politics in this State. This seemed so generally understood that we marvelled at his repeated re-election. We asked if his constituents did not think him corrupt? "Think it?" was the answer of one who knew, "they know it. He gets lots of State money spent in his county; that's why he is re-elected." It has been said that: "People are governed precisely as well as they deserve and desire." True. Engineers and others interested in better government should not overlook this fundamental truth.

CLASSIFICATION OF EXPENDITURES FOR IRRIGATION WORK.

Contributed by F. H. Newell, Professor of Civil Engineering, University of Illinois, formerly Director U. S. Reclamation Service, 1907-14, and Chief Engineer, 1902-7.

Throughout the western part of the United States there are almost innumerable canals each supplying water to hundreds or even thousands of farms. The works, owned by corporations or associations, are administered usually by engineers or men of engineering training generally designated as "Irrigation Managers" or "Superintendents." Their work is in many ways similar to that of superintendents of city water works, the principal difference lying in the fact that the conduits are usually open canals or ditches in earth instead of covered pipes, and the people with whom they deal are farmers living at relatively wide distances from each other as compared with dwellers in city houses.

As yet the system of management, if it may be so termed, is crude and not standardized. Each manager has developed his own way of doing things. Attempts have been made to hold conferences of irrigation managers, and at these to discuss better methods and to try to exchange information on details which will lead to greater efficiency and economy. One of the important matters widely considered by correspondence and discussion is that of the proper classification of expenditures for maintenance of the work and the arrangement of these expenditures in such manner, that comparison can be made between the various methods of maintenance of irrigation systems.

Ways of Classifying.—It is necessary that the irrigation manager have for guidance a full statement of all expenditures arranged in such groups or classes as to enable him to see at a glance where and for what purpose costs have been incurred. There is an infinite number of ways in which the expenditures may be classified, and whatever classification is adopted it is frequently necessary for particular purposes to have made special analyses or recomputation of expenditures. No two managers will be equally well satisfied with any one classification adopted, but each will desire to make certain modifications from time to time to give him a better grasp of the situation. There are, however, certain principles which are fairly well agreed upon as to lines of division of expenditures common to all irrigation systems.

The simplest form of classification is that of totaling separately the costs for labor and for materials, giving at the end of the month or year information as to the amount paid for each of these two principal items. In a large irrigation system, however, it is necessary to know the purposes for which these expenditures were made and it is often desirable to make comparison of cost between different systems. To do this there must be other classifications adopted based upon certain large features. For example, all irrigation works include a distributing system, but may not have water storage; thus to make useful comparisons, the expense of the distributing portion of each system should be separated from the expenses of storage so as to ascertain whether the cost of distribution in the one system is comparable with that in the other.

Following this line it has been found desirable to classify all expenditures for operation and maintenance under five general heads as follows: (a) Development; (b) Carriage; (c) Distribution; (d) Drainage and Flood Protection, and (e) Structure Depreciation.

Development.—The operation and maintenance expenses which are included under the head of Development are those which pertain to the outlay made for obtaining or controlling the water or for getting possession of it for example, by reservoirs which store the floods or by diversion dams taking it from the river, or by pumping plants lifting it from the natural water courses, or from wells or by other means of capturing the water and separating it from what may be called the wild or unregulated condition of nature. Included under this head may be the cost of dikes or drainage ditches for protecting the reservoirs and all of the subsidiary works which relate to the first or primary control of the water.

Carriage.—The expenditures which are made in transporting the water which has been captured or subdued by the development works are included under the head of carriage, such for example as the cost of operating and maintaining the main line canals or of the natural channels or water courses, which take the stored or pumped water from the point of original control or development to the head of the branch canals or laterals which in turn distribute it to the fields. Certain canal systems have had large expenditures in the way of long and expensive canals around rocky or treacherous hill slopes before the water reaches the vicinity of the irrigated lands. The cost of operating and maintaining these expensive main line canals for the carriage of the water from the reservoir or head works to the distribution system should obviously be considered separately in order to make useful comparisons of cost with those of canal systems which do not have the necessity for this large outlay.

Distribution.—The principal item of expense in connection with operation and maintenance is that of receiving and measuring water from the main canal into the branches and laterals and in turn delivering it to the farmers' laterals. Here is where there is not only the largest expense directly or indirectly, but where the greatest economy may be enforced in the use of water and where the greatest damage may result from lack of proper care and expenditure.

In cases of works, such as reservoirs or pumping plants for development of water and of main canals for its carriage, there are usually a relatively few obvious conditions to be met. Extravagance or penuriousness in this work is easily noted, but in the distribution system with its infinite number of small details there is the widest range for use of judgment and for display of sound business methods by which to secure the greatest efficiency and economy in operating and maintaining the distribution system and also in producing the best results on the lands of the farmers.

Drainage and Flood Protection.—In some irrigation projects there are local problems of drainage or of protection from floods which necessitate large outlay. For example, where the irrigable lands are very nearly level or sandy in quality great amounts of water are frequently used and the whole area becomes waterlogged, introducing the necessity not only for greater economy in the use of water but also of large expenditures for keeping the top of the water table below the ground surface. In other cases where the irrigable lands are on the flood plain of a large stream, it is sometimes necessary to protect these against annual or occasional floods by a system of dikes, the cost of maintenance of which should obviously be separated from the other expenditure in considering comparative costs.

Depreciation.—There is still another item of expenditure which should be considered in rounding out the full presentation of operation and maintenance costs, and that is the depreciation which is taking place. Unless the amount of this depreciation is ascertained from time to time it is impossible to know whether the irrigation system is being maintained properly. The condition is similar to that of a merchant with a large stock of goods; unless he ascertains at the beginning of the year the amount and value of the goods on hand and again takes account of stock at the end of the year, he can not find out whether he has actually made or lost money. His books may show an apparent gain, but his stock may have run down or on the other hand his accounts may appear as though he had lost money, but in fact he has accumulated valuable goods for the next year.

The same condition exists under an irrigation system. One manager may keep all structures in good condition and spend considerable sums of money in having every detail in first-class working order, delivering water promptly and promoting the prosperity of the country, but at an apparently large cost. Thus he may gain a reputation for extravagance. The next man may rigidly cut down every item, gain a reputation for economy, but do this at the expense of the system and with occasional failures which may be attributed to natural causes.

Without a carefully made inventory or depreciation account, it is impossible to show that the first manager with much larger apparent expenditures was really producing more economical results than the second with a smaller outlay. In other words, the item of depreciation is the keystone of the arch, or the connecting link, which sustains the whole structure of accounts and cost keeping. It is possible, of course, to depend upon general knowledge and on personal recollection; on smaller irrigation systems this is usually done. The depreciation is known in a general way and repairs are made only when absolutely necessary, to be charged usually not as an item of depreciation or of maintenance, but to capital account, thus serving to increase the apparent total cost of the system.

Operation and Maintenance Distinctions.—Throughout all of these primary or functional divisions of expenditure, namely,—development, carriage, distribution, etc.,—runs the two classes of work performed, viz.: first, operation; second, maintenance. That is to say, the expenditures following those for construction consist, first, of those which have to do with the operating of the reservoir or pumping works, and then those which are more closely connected with its maintenance or preservation. This division becomes more apparent in the items pertaining to distribution, where during the crop season most of the expenditures are for operation. Then after the crop season is ended in the northern lands the distribution system is cleaned and repaired and the principal expenses at that time are those for maintenance.

The maintenance charges are those arising from the destructibility of the irrigation system used in the development and distribution of water. These include necessary repairs to the system and provision for prevention of such destructibility. Owing to the fact that the maintenance of the works is going on simultaneously with operation, it is not always easy to separate closely those expenditures that should be classed under operation from those that should be classed under maintenance. In the main, however, there is little difficulty experienced in differentiating between the two classes of charges. The operation charges are from their natures derived from expenditures in the handling of water and consist usually of salaries paid to and supplies used by the irrigation manager and his various office and field assistants, such as clerks, inspectors, hydrographers, water masters, ditch riders, and gate tenders.

The maintenance charges result from expenditures for salaries and wages paid to and supplies and materials used by the irrigation manager and his various assistants and employees when engaged in repairing breaks, renewing structures and making improvements in the canal system after its construction. After the completion of an irrigation system after its construction, it is often necessary to line a canal, to provide additional riprap, to change the location of the canal slightly at some place, to use a different type of structure in some particular case or to provide additional structures for the purpose of avoiding heavy maintenance charges. Such work of betterment is properly chargeable to maintenance unless it is desired to keep a separate account of the betterment items.

Account Numbers.—The splitting up under various heads of the expenditures made from time to time involves a large amount of labor. For example, a bill of materials may be received from a dealer, this bill including charges for lumber and hardware used partly in repairing the headworks and partly in the maintenance of the distribution system, together with items which are chargeable to operation of other features of the work. It is seen that the picking out of these involves not only full knowledge of conditions but a large amount of writing, especially if it is necessary to repeat the words "charged to maintenance of canal head" or "charged to cleaning lateral."

To avoid this excessive clerical labor a system of symbols or numbers is usually adopted thus reducing the actual work to a minimum. For example, when the pay roll or bill of materials is received, the superintendent or clerk who knows of the transaction takes the voucher, goes over it rapidly and assigns the different items or parts of items to corresponding features of the work, these being indicated by appropriate symbols. For example, 9-0 $17 indicates that on the particular pay roll $17 is to be charged to the item of labor on concrete structure of main supply canal, etc. Thus on the back of the claim or voucher or on a slip attached to it will be placed two vertical columns of figures, the first giving the distribution symbols, and the second the amounts, the total of which agrees with the total payment made.

By transferring these amounts according to the symbols given in the first column the distribution can be quickly made and with the least amount of copying.

Various codes or systems of symbols are used. For example, a number followed by a dash will indicate the principal structure, as follows:

1-, Storage dam of masonry or concrete.
2-, Storage dam of earth.
3-, Diversion dam.
4-, Power plant operation and maintenance.

Another set of figures indicates the classification according to labor, materials, etc., as follows:

0, Salaries and wages, gate-tenders, watchmen and canal-riders.
1, Labor, men and teams.
2, Materials and supplies.
3, Travel and livery.
4, Depreciation on equipment (for office use only).
5, Camp Maintenance (for office use only).
6, Superintendence (gravity) (for office use only).
7, Engineering (for office use only).
8, General expense (for office use only).

Thus, as given above, 1-0 will be the salaries or wages on account of the storage dam, or 1-2 materials and supplies chargeable to the same dam, and so on, the use of these symbols saving a large amount of time and bringing the distributed expenditures into systematic order.

The development of such a system is a matter of slow growth. There is usually a tendency to elaborate it to a point where such a large number of items are kept that the results may be more confusing than helpful. In all of these matters it is essential to have clearly in mind the object to be attained or the kind of information needed and to confine the clerical work to obtaining a relatively few facts rather than so many that the manager is hindered rather than aided in reaching results.

The system of account numbers for operation and maintenance including betterments is similar to that adopted by many of the railroads. It is found that there will be required about 100 to 125 account numbers or even more if the system is complicated. Although such a system at first may appear to be unnecessarily elaborate, experience has shown that the clerical work is far easier than would be assumed from the description and that most of the operations which appear difficult are performed almost automatically, as the clerks handling these matters carry in their heads the account numbers and set them down far more quickly than they could write out any descriptive data (see article by H. T. Cory in the proceedings of the American Society of Civil Engineers, November, 1912, page 1402).

The time is approaching when all irrigation companies and similar public utility organizations will be required to keep accounts of this kind which can be compared with each other and from which conclusions can be reached regarding the relative efficiency and economy of the different systems of management.

Efficiency and Economy.—The object of any system of accounts or of recording and classifying expenditures is to secure the highest possible efficiency in the management consistent with economy in each detail. To bring about this result it is necessary, as before stated, to have accurate knowledge of the expenditures which have been made, and the liabilities incurred, rounding these out with an occasional physical valuation or by taking account of stock, by which it is possible to know whether the property itself has increased or decreased in value as a result of the management.

Attention has already been called to the fact that the classification of expenditures, or the mere statement of totals spent for various purposes, does not reveal the true conditions of efficiency and economy of operation and maintenance. It is possible for the works and the agricultural lands to deteriorate under a parsimonious management, and on the other hand by using good judgment in expenditures, the property can be greatly increased in value and usefulness. The mere statement that so much more or less has been spent than in a preceding year means little or nothing as regards the effectiveness of the service, unless it is joined with a full knowledge as to what has been accomplished.

Costs Large.—The costs of operating and maintaining a canal system are necessarily large. In the last ten years there has been a great change of opinion due to the accumulation of reliable data on this subject. At first it was assumed that these costs would be merely nominal, the opinion being based upon early conditions where a small group of farmers handled canals distributing water in continuous flow to large tracts and where the head gates, once set, were rarely changed, and where, as a result, from lack of care a large proportion of the irrigated lands was either not supplied with water or was ruined by an excess. In nearly all of these older systems from a quarter to a third of the best farms have thus been injured, and the small annual cost of operation and maintenance has been more than offset by the swamping of thousands of acres of land which otherwise would have been worth $100 or more per acre.

The fallacious ideas of cheap cost of operation and maintenance have been prolonged by the requirement of some of the states that the systems operating under the Carey Act should charge only a nominal rate, say, 35 ct. an acre, an amount which has been found to be only a third of the actual expense.

In any large system where water is economically handled and measured and where the works are maintained in good condition, the operation and maintenance cost can not be kept down much below $1.50 or $2.00 per acre. Usually when such cheap costs prevail the maintenance and depreciation are not considered and the canal system is allowed gradually to deteriorate while a showing is made of apparent small annual outlay.

There has been much misinformation regarding the actual costs and this has been increased by the efforts of interested parties to attract purchasers of irrigated lands by statements of the then prevailing low charges. The average of operation and maintenance for the whole arid region of the United States is over $1 per acre, but some of the larger private projects have agreed on prices as low as 35 ct. per acre or even less. The actual cost when properly entered may be to the company several times this amount, but this fact is usually concealed and the water users later awake to the realization that they cannot properly operate and maintain the system at this expenditure after the works have passed into other control.

The fallacious ideas regarding small costs are the result of the lack of a good cost-keeping system or by manipulation of an imperfect system, such that all extraordinary or large items are entered on the books if at all not as part of the regular operation and maintenance but are charged as new investment or added to the capital account. For example, following an unusually severe storm or cloud-burst, a flume or portion of a canal may be washed out necessitating an expenditure of $5.000 for replacement. This in such a defective bookkeeping system as just noted may be entered not as maintenance for that year but the money may be raised by special assessment and the account carried on the books as an added investment in the works.

All statements of remarkably small management cost should be viewed with suspicion and careful analysis given to ascertain whether these include all of the proper items. They should be verified by such knowledge as may be obtainable as to whether the system has been allowed to deteriorate during this period of small cost.

In the case of the larger modern canals built by the government or by large corporations, there are rarely found those conditions of ease or simplicity which prevailed on the older canals which were gradually developed by co-operative work. In the case of the more modern systems, they have been built in more difficult locations and with an elaboration of detail, which is lacking in the earlier simpler work and there has not been practicable the development from the outset of that spirit of co-operation which characterized much of the pioneer work. On the contrary, large numbers of men from various parts of the country and with different experiences, have been attracted by advertising and brought together; being located largely by chance on lands under an elaborate irrigation system which requires far more skill in its maintenance than the earlier more simple and crudely built works. In the early stages of settlement in these newer systems the time of the water user is more largely needed in cultivating his field. He can not be depended upon to respond for immediate calls of the watermaster to make repairs or to clean out the distributing system, but expects that this will be done for him by the central organization.

The water user finds it more profitable to pay for having this operation and maintenance work done by experienced men than to take his own time to do it. This means that the total costs as charged on the books are far higher in these modern systems than in the case of the older ones where the labor or the time of the individual water users in making these repairs or in cleaning out the ditches was not charged or considered in making up the estimate of total expenditures. In these, the majority of the farmers accepted as a matter of course the fact that they must clean out some miles of laterals in order to get water to their land and considered this, if at all, as part of the ordinary farming expense, rather than of the operating of the canal.

It thus happens that in making comparison of the alleged costs of operation and maintenance of some of the older simpler systems, the manager of the more modern canal may be discouraged by the fact that he finds it impossible to properly maintain his system at the small costs which are quoted to him. He should bear in mind that the conditions are frequently not comparable; that the cost of operation and maintenance as given frequently does not include those items such as he must insert on his books in order to have full account of the time and money spent on the system. In other words, in order to have a proper comparison, the manager of the up-to-date system must call for an analysis of these alleged low costs and inquire into the fact as to whether they include all the costs, especially the overhead charges and learn whether the canal system with which comparison is made has been deteriorating as a whole during this period of supposedly low cost of maintenance.

As an example of alleged low cost of operation and maintenance of one of the older canals of Utah, may be cited a case where the manager in good faith stated that the cost was only 48 ct. per acre. A more careful analysis of the figures given by his books, however, showed that by taking the actual acreage irrigated in successive years, the costs for 1912 were as follows:

	Cts. per acre.
General expenses and supervision	16
Operating	17
Maintenance	67

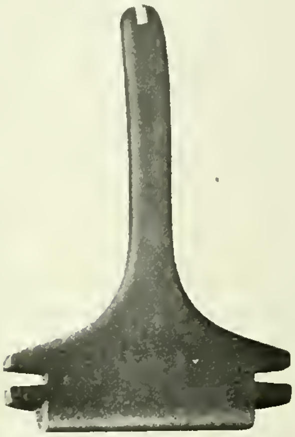
making a total of $1 per acre on the main canal alone of the operation and maintenance. To this should be added 42 ct. per acre for the work put by the farmers upon the sublateral system, which was not included in the expense of the canal itself. In the succeeding year, 1913, the figures per acre irrigated were for

	Per acre.
General expenses and supervision	$0.18
Operating	.16
Maintenance, including some replacement	1.18

a total for the main canal of $1.52, to which should be added the estimated cost of the lateral system of 42 ct., making a total of $1.94.

Instances of this kind could be cited where the man in general charge of the work, taking only a part of the figures, thoroughly believes that he is operating the works at a very low cost, whereas, if he had an analysis made in the same manner as that of one of the larger government canals, he would be surprised to find that his costs instead of being less are sometimes greater than in the case of the government works.

A WIRE TIE TIGHTENER FOR WALL FORMS.


Clamp for Tightening Wall Form Ties.

The tightener illustrated is applied on the front face studding. The tie wire is looped around the rear face stud and the two free ends are brought forward and through the front forms, one on each side of the front face stud. With the clamp laid against the face of the stud, handle up, the free ends of the wire are passed through the slots in the clamp head and tied together across the clamp. The clamp handle is then pulled down tight against the stud face and tacked fast by a nail in the handle slot. These clampers are used over and over. They are made in two sizes and are listed at $12 and $15 per 100. The American Metal Form Co., 1205 Fisher Building, Chicago, Ill is the manufacturer.

DATA ON THE REQUIREMENTS OF DIFFERENT BUILDING REGULATIONS AND AUTHORITIES GOVERNING REINFORCED CONCRETE COLUMNS.*

In Table I there are summarized the requirements of a large number of cities and authorities governing the design of concrete columns. The table was compiled from the various published building ordinances, some of which do not clearly express the limitations but have been interpreted literally as far as possible; the unit stresses are given in most cases so that there can be no misunderstanding.

There are a number of other points of comparison which might be made but which do not affect the unit stresses under discussion to any extent. The requirement for the ultimate strength of concrete at certain ages is specified in a large number of codes. Minimum sizes of columns, ratio of moduli of steel and concrete, maximum spacing and minimum area of vertical rods, minimum number and sizes of rods, and unit pressures for columns reinforced with structural steel are specified by many cities. There are many different ways of arriving at values for spiral reinforcement, and the notes appended to the table show some of these. A number of the city ordinances were undergoing revision at the time the table was compiled. The author has taken the latest information he could secure.

There are several general methods in vogue for determining the proportions of columns:

Rules based on the report of the Joint Committee are used quite generally. Rochester, Newark, Toronto and Louisville have ordinances very near these requirements.

The Chicago ordinance has been copied largely by some cities, notably, Seattle, Omaha and Winnipeg, and in a modified form by Detroit.

A third general class consists of those cities whose codes are based on Considere's formula and researches. Minneapolis, St. Paul and Columbus are examples of this class of cities.

Another method is that used by Philadelphia in specify-

---

*From paper by Pierce P. Furber before Convention, American Concrete Institute, Chicago, Feb. 14-17, 1916.

TABLE I.—REQUIREMENTS OF DIFFERENT BUILDING REGULATIONS AND AUTHORITIES REGARDING REINFORCED CONCRETE COLUMNS.

L = length of column; D = least diameter of column; d = least diameter of core; d' = least diameter of vertical rods; n = ratio of modulus of elasticity of steel to that of concrete.

Authority.	Mix.	Unit compression, plain concrete, lb. per sq. in.	Columns with vertical reinforcement and ties: f_c, Unit concrete compression, lb. per sq. in.	Verticals: f_s, Unit compression, lb. per sq. in.	Verticals, p: Minimum per cent.	Verticals, p: Maximum per cent.	Ties: Maximum spacing, in.	Ties: Minimum size of rod, in.	Hooped columns: f_c, Unit concrete compression, lb. per sq. in.	Hooping: f_h, Unit value as imaginary verticals in compression, lb. per sq. in.	Hooping, p': Minimum per cent.	Hooping, p': Maximum per cent.	Hooping, s: Maximum pitch, in.	Minimum wire, in.	Verticals: f_s, Unit compression, lb. per sq. in.	Verticals, p: Minimum per cent.	Verticals, p: Maximum per cent.	Maximum permissible unit compression on core, lb. per sq. in.	Minimum fireproofing outside steel, in.
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1. C. A. P. Turner, 1914	1:2:4	...	356	10,000	...	...	10d'[1]	¼ rd.	800	2.4×16,000	0.5	...	3	¼ rd.	12,000	...	8.0	2,000	1½
	1:1½:3	...	...	......	...	...	....	....	960	....	...	...	..	....	10,000	...	8.0	.....	...
2. Joint Committee, 1910	1:6	[2]	652[3]	9,780	1.0	4.0	0.25D	....	652	0	1.0	...	0.25D	....	9,780	1.0	4.0	.....	2
3. Am. Conc. Inst., 1910	1:6	650	450	6,750	...	...	0.25D	....	540	0	1.0	...	0.25D	....	6,750	...	...	.....	[4]
	....	...	...	......	...	...	....	....	650	0	1.0	...	..	....	9,750	1.0	4.0	.....	2
4. Nat. Bd. Fire Und., 1915	1:6	500	500[3]	6,000	0.5	3.0	15d'[5]	¼ rd.	750	0	1.0	...	1/6d[6]	¼ rd.	9,000	1.0	4.0	.....	2
	1:4½	600	600	7,200	...	...	....	....	900	....	...	...	..	....	10,800	...	...	.....	...
5. Boston, 1912[7]	1:6	416	416	4,160	...	...	....	....	.....	....	...	...	..	....	......	...	...	.....	1½
	1:5	370	370	3,700	...	...	....	....	.....	....	...	...	..	....	......	...	...	.....	...
6. Providence, 1913[8]	....	...	...	......	...	...	....	....	.....	....	...	...	..	....	......	...	...	.....	...
7. New Haven, 1914	1:2½:5	...	500[3]	6,000	0.5	1.0	¼D	1%	1,000	0	1.0	...	1/8d	[9]	12,000	0.5	1.0	.....	1½
8. Waterbury, 1914	1:2:4	400	400	0	0.5	...	12	¼ rd.	600	[10]	...	...	1/7d	¼ rd.	0	0.5	...	.....	2
9. New York, 1915	1:6	500	500	7,500	0.5	4.0	[5]	....	500	[10]	0.5	2.0	[6]	....	7,500	1.0	4.0	.....	2 [11] [12]
10. Rochester, 1914	1:6	650	450	6,750	...	...	¼D[13]	....	650	0	...	...	0.25D	....	9,750	1.0	4.0	.....	1½ [4]
	....	...	650	9,750	1.0	4.0	....	....	.....	....	...	...	..	....	......	...	...	.....	...
11. Syracuse, 1913	1:2:4	...	500[3]	7,500	1.0	...	D, 12	....	650	0	1.0	...	..	....	9,750	...	...	.....	... [4]
12. Buffalo, 1915[14]	1:2:5	350	350	1,200	...	...	D	....	.....	....	...	...	..	....	......	...	...	.....	...
13. Newark, 1911	1:2:4	...	450	6,750	...	...	D, 12	¼ rd.	540	0	1.0	...	..	¼ rd.	8,100	...	...	.....	2
	....	...	...	......	...	...	....	....	650	0	1.0	...	..	....	9,750	1.0	4.0	.....	...
14. Philadelphia, 1914[15]	....	500	500	0	...	...	d	....	1,000	0	...	...	1/9d[16]	....	0	...	...	1,000	2 [17]
15. Baltimore, 1908	1:2:4	400	500[3]	0	...	6.0	12	....	1,200	0	...	...	..	....	0	...	...	1,200	2 [18]
16. Pittsburgh, 1913	....	450	540	8,100	1.0	4.0	[19]	⅛ rd.	[20]	[20]	0.5	...	[6]	⅛ rd.	......	1.0	4.0	.....	1½
17. Cleveland, 1911[19]	1:2:4	500	500	10,000	1.0	10.0	12	....	500	....	...	...	..	....	10,000	1.0	10.0	.....	2
18. Toledo, 1912[21]	1:2:4	350	...	......	...	...	....	....	.....	....	...	...	..	....	......	...	...	.....	...
19. Detroit, 1914	1:1½:3	400	550	6,600	0.5	4.0	12d'	....	650	18,720	0.5	1.5	0.1d[22]	....	7,800	0.5	8.0	.....	1½
	1:1:2	...	...	......	...	...	....	....	750	21,600	...	...	..	....	9,000	...	...	.....	...
20. Columbus, 1913	1:2:4	...	500	7,000	0.5	1.0	[23]	0.625 sq. in.	700	2.4×10,000	0.5	1.5	[24]	5/16 rd.	10,000	...	...	.....	2 [25] [26] [27]
	....	...	...	......	...	...	....	....	.....	2.4×12,000[28]	...	...	..	....	......	...	...	.....	...
21. Cincinnati, 1913	1:2:4	200	600[3]	10,800	1.0	...	12	0.0625 sq. in.	600	2.2×10,800	1.0	...	1¾	0.0625 sq. in.	10,800	1.0	...	.....	1
	1:1½:3	...	700[3]	10,500	...	...	....	....	700	2.2×10,500	...	...	..	....	10,500	...	...	.....	...
22. Louisville, 1913	....	650	650	9,750	1.0	4.0	12	....	650	....	...	...	..	....	9,750	1.0	4.0	.....	1½
23. Indianapolis, 1913	1:2:4	440	450	6,750	0.5	4.0	12d', 12	....	610	0	1.0	1.5	⅛d, 2½	....	9,600	p'	5.0	.....	2
	1:1½:3	...	540	6,180	...	...	....	....	768	....	...	...	..	....	9,216	...	...	.....	...
	1:1:2	...	652	6,520	...	...	....	....	928	....	...	...	..	....	9,280	...	...	.....	...
24. Grand Rapids, 1913	1:2:4	[29]	600[3]	8,000	[30]	[30]	[31]	0.1104 sq. in.	800	2.4×16,000	...	...	1/7d	0.0767 sq. in.	10,000	...	...	.....	1½ [26] [27] [33]
25. Chicago, 1911	1:2:4	...	400	6,000	0.5	3.0	12d', 18	....	500	18,750	0.5	1.5	0.1d, 3	....	[33]	p'	8.0	.....	1½
	1:1½:3	...	480	5,760	...	...	....	....	600	18,000	...	...	..	....	[33]	...	...	.....	...
	1:1:2	...	580	5,800	...	...	....	....	725	18,125	...	...	..	....	[33]	...	...	.....	...
26. Milwaukee, 1914	1:2:4	[34]	500[3]	7,500	...	...	12	¼ rd.	800	0	1.0	...	3	¼ rd.	12,000	1.0	6.0	.....	1½
	1:1½:3	...	...	......	...	...	....	....	900	....	...	...	..	....	13,500	...	...	.....	...
27. St. Louis, 1914	1:2:4	...	500[3]	7,500	1.0	...	20d'	0.03 sq. in.	500	2.4×14,000	...	...	0.1d	0.03 sq. in.	14,000	...	...	.....	2 [35]
	....	...	...	......	...	...	....	....	.....	2.4×20,000	...	...	..	....	20,000	...	...	.....	... [28]
28. Kansas City, 1915[21]	....	...	...	......	...	...	....	....	.....	....	...	...	..	....	......	...	...	.....	...
29. Minneapolis, 1911	1:2:4	[29]	600[3]	8,000	[30]	[30]	[31]	0.1104 sq. in.	800	2.4×16,000	0.5	1.5	1/7d	0.0767 sq. in.	10,000	...	5.0	1,830	1½ [25] [26] [27] [36]
30. St. Paul, 1910	1:4	[29]	500	7,500	...	...	12	¼ rd.	750	2.4×16,000	0.5	2.0	[24]	¼ rd.	10,000	p'	7.0	.....	2 [38]
31. Duluth, 1912	1:2:4	350	500[3]	8,000	[37]	[37]	[23]	0.1104 sq. in.	600	2.4×16,000	...	...	1/5d, 7d	0.0767 sq. in.	12,000	...	...	.....	1½ [27] [38] [39] [40]
	1:2:4	...	600[3]	8,000	[30]	[30]	[31]	....	.....	....	...	...	..	....	......	...	...	.....	...
	1:1½:3	...	...	......	...	...	....	....	750	....	...	...	..	....	......	...	...	.....	...
32. Omaha, 1912	1:2:4	...	400	6,000	0.5	3.0	12d', 18	....	500	18,750	0.5	1.5	0.1d, 3	....	[33]	p'	8.0	.....	1½
	1:1½:3	...	480	5,760	...	...	....	....	600	18,000	...	...	..	....	[33]	...	...	.....	...
	1:1:2	...	580	5,800	...	...	....	....	725	18,125	...	...	..	....	[33]	...	...	.....	...
33. Denver, 1905[21]	....	...	...	......	...	...	....	....	.....	....	...	...	..	....	......	...	...	.....	...
34. Seattle, 1914	1:2:4	...	450[3]	6,750	0.5	5.0	[41]	¼ rd.	500	18,750	0.5	1.6	[24]	¼ rd.	[33]	p'	7.5	.....	1½ [42]
	1:1½:3	...	540	6,480	...	...	....	....	600	18,000	...	...	..	....	[33]	...	...	.....	...
	1:1:2	...	652	6,520	...	...	....	....	725	18,125	...	...	..	....	[33]	...	...	.....	...
35. Portland, Ore., 1911	1:2:4	500	500	7,500	1.0	4.0	D	....	750	2.4×11,250	0.5	1.5	1/6d	....	11,250	p'	5.0	.....	2
36. San Francisco, 1910	1:6	500	500	7,500	1.0	5.0	d	0.05 sq. in.	700	0	...	...	0.1d	....	10,500	1.0	5.0	.....	2 [43]
37. Los Angeles, 1914	1:2½:3½	[44]	550	8,250	1.0	5.0	d, 15d'	3/16	800	0	0.5	...	3	[45] 3/16	12,000	1.0	7.5	.....	1½
	1:3:4½	[44]	440	6,600	...	...	....	....	.....	....	...	...	..	....	......	...	...	.....	...
38. Memphis, 1913	1:2:4	650	650	9,750	0.5	...	D, 12	¼ rd.	800	[15]	1.0	...	1/7d	¼ rd.	12,000	1.0	...	1,100	1½ [45]
	1:1½:3	750	750	9,000	...	...	....	....	900	....	...	...	..	....	10,800	...	...	1,300	...
	1:1:2	850	850	8,500	...	...	....	....	1,070	....	...	...	..	....	10,700	...	...	1,500	...
39. Richmond, 1912	1:2:4	500	500	7,500	1.0	10.0	12	....	.....	....	...	...	..	....	......	...	...	.....	2 [46]
40. Atlanta, 1911	1:2:4	...	600[47]	6,000	...	...	D	5/16	.....	....	...	...	..	....	......	...	...	.....	1 [48]
41. New Orleans, 1913[21]	....	500	...	......	...	...	....	....	.....	....	...	...	..	....	......	...	...	.....	...
42. Toronto, 1913[15]	1:2:4	...	450[3]	6,750	1.0	4.0	d, 12	¼ rd.	650	0	1.0	...	1/6d, 3	¼ rd.	9,750	1.0	4.0	.....	2 [4]
43. Winnipeg, 1913	1:2:4	...	500	7,500	0.5	3.0	12d', 18	....	600	22,500	0.5	1.5	0.1d, 3	....	[33]	p'	8.0	.....	2

NOTES TO TABLE I.

[1] 10d′ or 9 in.

[2] 450 for $\left(\frac{l}{D} < 12\right)$.

[3] On core.

[4] If a richer mix is used increase the concrete unit stress in proportion to the increase in ultimate strength, but not more than 25 per cent.

[5] 15d′ or 12 in.

[6] 1/6d or 3 in.

[7] Rules regarding columns may be formulated by the Commissioner of Buildings.

[8] No requirements for unit stresses.

[9] Diameter in inches = $\frac{1}{8}$S.

[10] For cylindrical columns reinforced with bands or spirally wound hooping, allow on the hooping 3.14 times lateral resistance of hoops when stressed to not more than 16,000 lb. per square inch, provided there is enough hooping to insure a lateral resistance of 65 lb. per square inch, but not to exceed 100 lb. per square inch.

[11] Increase concrete stress 20 per cent for 1:1½:3 mix.

[12] Wire for hooping must be drawn from billets and have an ultimate strength of at least 85,000 lb. per square inch.

[13] $\frac{1}{4}$D or 12 in.

[14] No specifications for hooped columns.

[15] Ordinances being revised when this table was prepared.

[16] 1/9d or 3 in.

[17] Spiral and vertical steel must be sufficient to develop a factor of safety of 4 on concrete. The area of hooping per inch of height must be W/65,000πd, where W is the total load.

[18] The percentage of hooping and vertical steel (p and p′) must be sufficient to develop a factor of safety of 6.

[19] 16d or the distance center to center of corner rods.

[20] The Pittsburgh code has the following formula for the strength of hooped columns:

$$\left(A_c + nA_s\right)\left(750 + 4.8\frac{16,000A_y}{Sh}\right)$$

where A_c is the area of the core in square inches, A_s is the area of the vertical steel, A_y the area of the hooping steel, S is the pitch and h is the diameter of the core in inches. For exterior columns the units are reduced 20 per cent.

[21] No specifications.

[22] 0.1d or 3 in.

[23] 12 in. or half the distance center to center of verticals.

[24] 1/7d or 3 in.

[25] For exterior columns, reduce units 20 per cent.

[26] Properly welded bands may be used in place of spiral; spacing of bands not to exceed 7d′.

[27] Spirals must be continuous, machine-made and provided with accurate spacers in order to use these values.

[28] High carbon steel.

[29] With L/D less than 5, 500; with L/D greater than 5 and less than 12, 300.

[30] Eight rods.

[31] 7d′ or 12 in.; two sets.

[32] If wire not less than 5/16 in. diameter is used for spiral, allow 25,000 instead of 16,000 in column 11.

[33] Varies with p′, viz.: $nf_c\ (1 + 2.5np')$.

[34] 400 for L/D less than 8.

[35] Medium steel.

[36] p and p′ may be greater than tabulated, the allowed unit stresses to be determined by the building inspector.

[37] Four rods.

[38] If the spiral wire is at least 5/16 in., the ultimate strength is 80,000 lb. per square inch and the elastic limit is 50,000 lb. per square inch, allow 20,000 instead of 16,000 in column 11.

[39] If S is more than 0.2d, reduce the unit stresses 50 per cent of the proportional increase of spacing.

[40] Concrete unit stresses may be increased 15 per cent for concrete 2 years old.

[41] 15d′, d or 18 in.

[42] Spirals must have three spacers.

[43] Hooping must be designed to resist tension due to unit lateral pressure of one-fifteenth of the unit compression on concrete.

[44] Not allowed for columns.

[45] Hooped columns to be computed according to rules approved by building commissioner.

[46] For buildings over four stories high steel must carry 75 per cent of dead load at 1,000 lb. per square inch, except where in buildings of any height concrete will carry LL + DL with f_c less than 500. Steel must not be less than 1 per cent or more than 10 per cent.

[47] This value is for columns carrying balanced loads; for columns with balanced loads on two sides and one unbalanced load, the value is 500, and for columns with two unbalanced loads it is 400.

[48] p must be at least 1.5 for columns where L/D is 12 to 14, at least 1.25 for L/D = 10 to 12, and at least 1.0 where L/D is less than 10.

[49] Hooping stress not greater than two times unit tension allowed on steel, not greater than 20,000 lb. per square inch, and not greater than one-third the elastic limit for drawn wire.

---

ing a fixed value for the concrete when a minimum percentage (1 per cent) of spiral is used and nothing is allowed on vertical steel.

A number of cities, as San Francisco, Milwaukee, Indianapolis and Cleveland, specify unit stresses for concrete with a minimum percentage of spiral and allow no value for the spiral directly. The vertical steel is allowed a stress of nf_c, where n is the ratio of moduli of steel and concrete. This is somewhat along the line of the Joint Committee recommendations, but variations in the stresses are usually made. Cincinnati allows no greater value on the concrete of hooped columns than on tied columns, although the stress allowed on hooping is supposed to take care of the increase in strength.

In comparing the various requirements it is remarkable to find such general disagreement among the framers of ordinances. There is much room for improvement and a need for revision of a large part of the present laws. This is especially true when we consider that it should be well known that many of the ordinance values do not correspond with values determined from tests of columns.

WHAT IS A SPECIAL?

To the Editors: A question has recently came up on a water pipe line contract totaling approximately $500,000 which seems to merit some discussion. The work was done under a unit price proposal and the question hinges on what constitutes a "special."

The specifications called for the contractor to furnish, haul and lay cast iron pipe at a bid price per ton and to furnish, haul and lay cast iron pipe specials at another bid price per ton.

The straight pipe was to lay about 12 ft. and the specifications gave the approximate number of 12-ft. lengths required, also the approximate number of tons of specials required.

In the actual construction a considerable quantity of the straight pipe had to be cut and fitted to valves and specials. This involved a considerable outlay, as the bulk of the work was 48-in. pipe in which the cutting was expensive and the number of extra joints so required ran into considerable money. The 48-in. joints being 3½ in. deep, cost about $9 each. Under the specifications the waste cut pipe under 6 ft. in length was a total loss to the contractor.

The question therefore is: "Does the cut pipe, involving an extra joint and a loss of the waste end, constitute a special?"

The writer was Engineer for the contractor on this work. An expression of opinion on this matter would be appreciated.

Very truly yours,
EARL M. SEITZ, Engineer.

Goff Bldg., Camden, N. J.

(Here is a point worthy of discussion, as our correspondent says. We shall be glad to give space to an expression of opinion on the subject. Let us note, in passing, that in drawing up the specifications to govern the laying of pipe lines that the wording should be such as to leave no doubt as to what constitutes a special. In the editor's opinion our correspondent's question should be answered in the negative. The cut pipe should have been provided for in the contract price charged. The term "special," as ordinarily used, is merely a contraction of "special casting" and includes nothing else than the standard specials familiar to all. Separate account should be taken in the bid of waste lengths of short pipe.—Editors.)

SOME TESTS ON HYDRATED LIME ADDITION TO CONCRETE FOR ROAD WORK.*

By Ernest Ashton, Chemical Engineer, Lehigh Portland Cement Co.

The questions to which answers were sought were:

(1) Does the addition of hydrated lime increase the mobility of concrete?

(2) With a given angle of chuting and given percentage of water, will concrete flow more readily if hydrated lime is added?

(3) Does the addition of hydrated lime aid in preventing segregation?

(4) Acting as a void filler, will the addition of hydrated lime tend to make the mass more impervious, thereby reducing to the minimum alternate expansion and contraction due to moisture?

All mixes were made with the addition and not substitution of high calcium hydrate by weight, mixed for 1 minute and designated as H5, 10, 15 and H145, 1,410 and 1,415. The slope was maintained at a 20-degree angle.

COMPRESSION TESTS OF CONCRETE.

	Compressive strength. Unit stress lb. per sq. in.		Remarks.
Mark.	1 mo.	2 mo.	
H5	3,880	4,970	20° slope of chute; 5% hydrated lime; 12 notches water. Mixing 1 min. Very sticky. No separation of materials. Pushed down chute. All specimens poorly compacted.
	4,590	4,880	
	3,800	3,910	
Average	4,090	4,580	
H10	4,320	5,240	Same as H5 except 10% lime. More sticky than H5 Second specimen poorly packed; other two only fairly well packed.
	4,890	5,310	
	4,680	5,460	
Average	4,630	5,330	

---

*Appendix to committee report on Mixing and Placing Concrete, National Conference on Concrete Road Building.

H15	4,740 4,260 4,270	4,890 5,250 5,320	Same as H5 except 15% lime. Still more sticky. All materials held well together in mass. All specimens poorly compacted.
Average	4,420	5,150	
H145	2,870 2,850 2,930	3,280 3,120 3,340	20° slope of chute; 14 notches water; 5% lime. Very soft and easy flowing. Similar to B2.
Average	2,880	3,250	
H1410	4,140 4,410 4,320	5,010 5,040 5,040	20° slope of chute; 14 notches water; 10% lime. Not as soft as H145; flow was slower.
Average	4,290	5,020	
H1415	3,850 4,250 4,520	4,220 4,620 4,990	20° slope of chute; 14 notches water; 15% lime. Appearance and flow same as H1410.
Average	4,210	4,620	

(1) No greater freedom of movement of the mass was noticed; in point of fact, as the lime was increased more difficulty was experienced in getting the material into the test forms.

(2) The work done shows that with same angle and same percentage of water concrete did not flow more readily by the addition of hydrate of lime and as the percentage of hydrate of lime was increased the mass became more sticky and did not flow as readily.

(3) By far the most important observation made was that the addition of hydrate of lime did prevent segregation and so much so as to make this the biggest gain that can be gotten from the use of hydrate of lime.

The number of specimens made was too small to make an adequate interpretation of actual values, and it is the intention of the committee to carry on during this year a more extensive investigation as to the value of adding hydrated lime. In this connection we call attention to the fact that the Bureau of Standards, at Pittsburgh, has already started some work along this line.

COST OF REINFORCED CONCRETE RETAINING WALL AND OF SPECIAL METHOD OF HANDLING COAL.

(Contributed.)

This article may interest readers who are in a similar predicament to that experienced by the writer when it was found necessary to devise a scheme for cutting the cost of delivering and unloading coal in front of a battery of boilers. The coal being delivered to the plant mainly by barge was formerly transferred by crane to cars which, after being hauled to the desired location, were shoveled out by hand. This was expensive and left an unsightly pile—too close to the rail for safety. Local conditions, traffic, etc., would not permit of constructing a trestle so that the cars could be dumped; therefore an elevated car was constructed of 30 tons capacity, with doors high enough to dump over a retaining wall upon being automatically released.

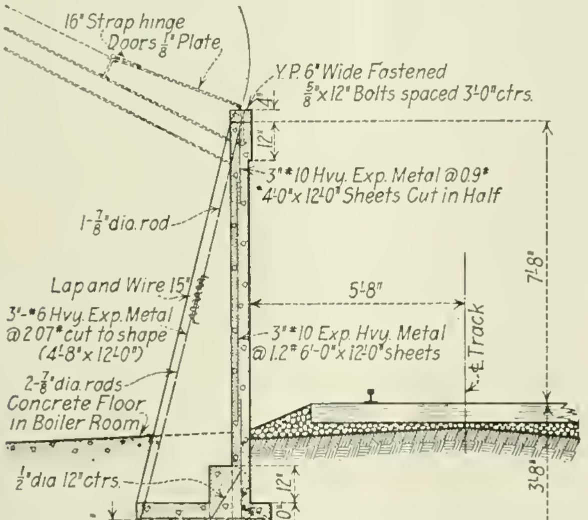

16" Strap hinge
Doors $\frac{1}{8}$" Plate
Y.P. 6" Wide Fastened
$\frac{5}{8}$"x12" Bolts spaced 3'-0" ctrs.
4"
12"
3" *10 Hvy. Exp. Metal @ 0.9*
4'-0"x12'-0" Sheets Cut in Half
1-$\frac{7}{8}$" dia. rod
7'-8"
Lap and Wire 15"
5'-8"
3'-*6 Hvy. Exp. Metal @ 2 07* cut to shape (4'-8"x12'-0")
3" *10 Exp. Hvy. Metal @ 1.2* 6'-0"x12'-0" sheets
℄ Track
2-$\frac{7}{8}$" dia. rods
Concrete Floor in Boiler Room
$\frac{1}{2}$" dia 12" ctrs.
12"
3'-8"
10"
3$\frac{1}{2}$"
8" 5" 8"
7-$\frac{7}{8}$" dia 5" ctrs.
$\frac{3}{8}$" distributing Rods 12" ctrs.
3'-6"
3" *6 Std Exp. Metal @ 1.38*
3'-6"x12'-0" Sheets
Length of Wall 92'-10$\frac{3}{4}$": Counterforts sp. 11'-6$\frac{1}{2}$" c.c

Fig. 1—Section of Retaining Wall for Coal Storage.

The wall was built of reinforced concrete, of a section given by Fig. 1, the method used in constructing being one given in Engineering and Contracting about 1908. This scheme brought the cost of form-work down to a minimum, only two complete runs of 1x12-in. plank being used for the wall proper; these with the assistace of slotted studs, were raised daily, 2 ft. of concrete being a day's work. The only built-up forms on the job were for the counterforts.

The total cost of the wall was quite low, amounting to only $446.10; $14.97 per cubic yard or $4.84 per lineal foot.

The itemized costs were as follows:

Hauling	$ 15.64
Excavation	12.36
Concreting and raising forms	127.17
Blacksmith	2.45
Carpenters	22.06
Total labor	$179.68
Reinforcing bars	42.92
Expanded metal	62.74
Bolts, nuts and washers	12.84
Lumber	37.36
212 bags cement	57.38
20 tons of sand	23.75
34 tons of stone	40.28
Nails	0.59
Wire	0.56
Total materials	$266.42
Grand total	446.10

The cost of forms was $2.41 per cubic yard or 77 ct. per lineal foot of wall. The time saved by using the elevated dump car instead of unloading by hand is shown by the following comparison:

ORDINARY CAR. (Contents, 30 tons.)		HIGH CAR. (Contents, 30 tons.)	
Locomotive to weigh and set car	15 min.	Crane to load	15 min.
5 men to unload by hand at 2 hr. each	10 hr.	Locomotive to weigh and set car	15 min
		Boiler firemen to unload same	10 min.
		Locomotive and return	5 min.
Total	10 hr. 15 min.	Total	45 min.

In constructing the retaining wall labor was paid 16⅔ ct. per hour. On bolts and nuts $9 was salvaged and is not included in total cost.

SOME EXPERIENCES WITH LEADITE JOINTS AT SPRINGFIELD, MASS.*

By A. E. Martin, Superintendent of Water Works, Springfield, Mass.

In Springfield, Mass., we have had a little experience with Leadite during the last year. We laid perhaps half a dozen miles of 8-in. pipe in 1915 with Leadite joints and have had very good results. But one or two experiences on a little larger scale are of special interest. Of course, in commencing its use we asked the Leadite men for help, and one of their representatives came to us to show us how to melt it. We had to make an 8-in. connection with a 30-in. line, using the tapping machine and split sleeve, and asked him if he would advise the use of Leadite in making the joint. He assented and poured the joint with Leadite, and when the water first came while tapping the pipe it leaked very fast. We were afraid of it, but he said, "Keep on." We made the cut and when we got it made the leak virtually stopped. We left it open 24 hours after making the connection with the line and it was perfectly tight at the end of that time. But a peculiar thing about the job was that we had not used Leadite in laying the 8-in. pipe connection to it, and in driving the lead joints of the connection near this tap, we loosened the sleeve joint and got lots of water again. He still said, "Let it rest and I will guarantee it will be tight in 24 hours,"—and it was. The joint still "rests," and we have had no trouble with it. We have tapped the 30-in. pipe a number of times during the last year, using Leadite for the joints, and have had no trouble.

We have made one 8-in. tap off a 36-in. pipe for a hydrant connection, where we have a working pressure of 150 lb. The joint acted in much the same way and we were rather timid about it. The representative was not with us at that time. But within 24 hours the leaks had entirely ceased.

---

*A discussion printed in the Journal of the New England Water Works Association for December, 1915.

We have still some cement-lined iron water mains in Springfield, and among others a 24-in. supply line from the old Ludlow reservoir. We have had to tap that main in several places, and in the first tap we made, we had bad luck with the Leadite; we left the joint for 24 hours, but there was apparently no difference in the leak. The foreman did not want to take off the sleeve and run the joint again and I did not want to cut the pipe and put in a T, so I allowed him to experiment with it. He shut the water off, draining it below the outer joint, and then cut the Leadite out completely through the sleeve, right in the neck of the valve. Then he ran that part of the joint over again, and it came out perfectly tight—and we have no further trouble with it.

A PAVING MIXER WITH A STEEP ANGLE CHUTE AND AN AUTOMATIC WATER WEIGHING DEVICE.

The concrete paving mixer shown by the accompanying illustration has two distinctive features deserving of attention. The first feature is the high mounted drum which permits the use of a steep-angle discharge chute; the second feature is a water measuring tank which automatically weighs the water content of the batch. By means of the high elevation of the drum an angle of 20 degrees is readily given to the distributing chute. Any concrete of ordinary consistency will flow in a chute of this inclination. The new chute construction, therefore, meets the demand now becoming prevalent for drier mixtures for paving work. Another feature of the chute construction that will be noted from the illustration is the auxiliary chute which slides on the main chute and has a full-circle swivel joint. This secondary chute provides for depositing the concrete anywhere within the radius of the main chute. Intermediate gates in the main chute divert the flow into the auxiliary chute at will.

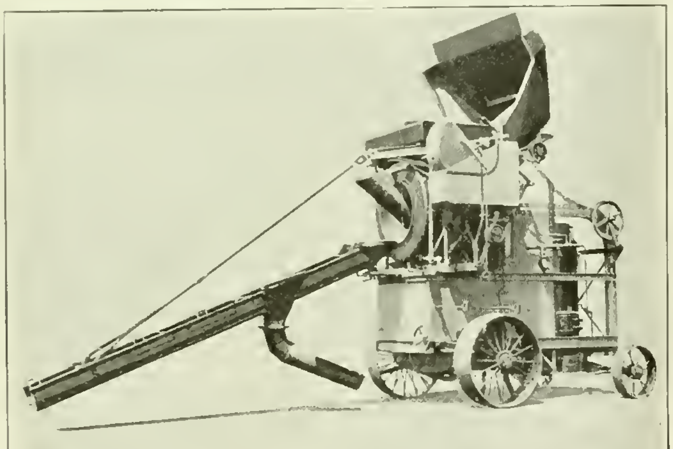


Fig. 1—High Drum Paving Mixer With Stop Chute. Fig. 2—Automatic Water Weighing Tank.

The automatic measuring tank is seen in place on the side of the mixer in Fig. 1 and is explained in diagram by Fig. 2. Referring to the second illustration the measuring tank is a semicylindrical and is mounted in such a way that it will freely pivot, thus allowing it to be easily tilted. The balance weight is on a notched arm so it may be placed at any point and balance the weight of the tank plus the water required for a batch. As soon as the measuring tank is emptied the balance weight drops and the tank is forced upward about 3 in. When in this position, it lifts the valve, which opens upward, allowing the water to flow from the storage tank into the measuring tank.

The tank sinks when enough water has been drawn to overbalance the adjustable weight, and the weight of the water in the storage tank automatically closes the rubber-seated valve. This is so tight that there can be no leakage. When the skip is hoisted, the front rollers engage a bell crank which works through a train of levers, automatically tilting the measuring tank. The water, as this tank tilts, flows into the collecting tank which surrounds it and from this collecting tank runs through the pipe into the mixer drum. The flow of water is so arranged that it enters the drum simultaneously with the batch from the skip. The water is sprayed through the batch before it reaches the bottom of the drum.

The new mixer described has all the improved appliances characteristic of its type besides the two special features described. It is asserted to be absolutely a one-man mixer. It is made by the T. L. Smith Co., 3106 Hadley St., Milwaukee, Wis.

IS THE ACTIVATED SLUDGE PROCESS OF SEWAGE TREATMENT TO BE PATENTED AGAIN?

After many years of litigation of one sort and another the Cameron Septic Tank Patents are still matters of concern to the engineers and city officials of this country. Probably every engineer hopes disputes of this kind can be avoided in future. It was thought that there was no danger of trouble in the United States over patents on the activated sludge process, and perhaps there will not be. However, that point remains to be settled. Mr. T. Chalkley Hatton, chief engineer of the Milwaukee Sewerage Commission, spoke as follows with reference to this matter, in his recent paper before the Indiana Engineering Society:

Dr. Gilbert J. Fowler of the Manchester University, England, who for many years was consulting chemist to the Manchester Corporation, was the real discoverer of the process, if it can be considered a discovery rather than a combination of well known principles. At any event the English Patent Office considered it of sufficient originality to grant letters patent to Messrs. Jones & Attwood, Manufacturing Engineers, of Stourbridge, England, to whom Dr. Fowler turned over his interests. This firm has applied for American letters patent, which application is now pending.

In the meantime Mr. Leslie C. Frank, Sanitary Engineer with the United States Public Health Service at Washington, D. C., applied for and was granted letters patent for the application of the process on the continuous flow principle, and dedicated his patent to the citizens of the United States, thus showing an unusual foresight and magnanimity which, I am sorry to say, few engineers show.

How the letters pending from Jones & Attwood, if granted by the United States Patent Office, may affect the probable use of the process in this country it is now impossible to foretell; but from a close study of the English patents by the author, it appears they are granted upon apparatus rather than process, whereas the Frank patents cover both apparatus and process.

There is so much similarity between the Frank patents and the claims in the pending applications of Jones & Attwood that it would appear as though the United States could not be warranted in issuing letters patent to the latter gentlemen. If it does, subsequent litigation only will settle the question.

It is the author's opinion, however, that American municipalities would be running very little risk of paying royalties should they install plants utilizing the activated sludge process, inasmuch as the majority of the apparatus patented by Jones & Attwood is not essential to the proper operation of the process.

THE DESIGN AND CONSTRUCTION OF FORMS FOR CONCRETE WORK.*

By R. A. Sherwin, Aberthaw Construction Co., Boston, Mass.

In this paper the writer proposes to discuss the subject of forms for concrete work and to describe the methods used in handling form work by the Aberthaw Construction Co., with which the writer is connected.

I.

Numerous cost-analysis diagrams prepared in our office from the actual costs of average reinforced concrete buildings of the industrial type, not taking into account the cost of any equipment, show that the labor on forms averages about one-third the labor cost, which is about 35 per cent of the total cost of the building, and the lumber about one-tenth of the total material cost, including subcontracts. The design and erection of forms is therefore the most important single item in concrete building construction and one upon which much thought and study can be well spent. Exchange of ideas by those familiar with concrete forms will be profitable to all concerned.

I do not propose to go into the mathematics of form design as extensively as did Mr. H. S. Taft, in a paper before the 1915 convention. However, I do propose to show the relation between the important features of form work and to show how we have successfully reduced the cost of forms by a careful study of their design, buying materials, and field work. I shall introduce some tables and figures to show how we apply the theory of mechanics to a problem which has too many variables to admit of any rigid solution. These tables have been found practicable for use and have given safe results.

I do not agree with the following extract from an article on forms by Mr. Jerome Cochrane, in the June, 1915, number of the Concrete Cement Age: "Too much stress cannot be placed upon the importance of having an ample number of shores under the forms, which should be regulated by the judgment of the foreman or boss carpenter." This is a question of design, and a drawing should be given the foreman which will give him all the important information in regard to supporting the forms.

The same author in the March, 1915, issue of the same paper writes in part as follows: "Plans and details for forms, if required to be furnished by the contractor, should be submitted to the engineer for his approval before starting the work, but such approval should not release the contractor from any responsibility, etc." I do not believe this is the correct position to take in this matter. The engineer should be interested in results only. The finished building must be as he specifies. Since he holds the contractor responsible for results, the methods of doing the work should be left to the contractor entirely. The engineer has his work in designing the structure. The contractor ought to know more about designing forms. It is his business to know how to build.

General Problem.

Economical forms must be designed as light and with as few sticks as are required to give the necessary strength and stiffness. You will note I say "necessary," for this is the point to keep in mind. We must remember on the one hand that human lives and the cost of failure both in money and reputation are dependent upon the design, and on the other hand that form work is a temporary structure fully loaded for a short time only and a lower factor of safety is therefore allowable.

The main question then is one of strength with enough stiffness to prevent any appreciable sags in the finished concrete. Any slight deflection that might occur in the timbers themselves is taken care of in the camber, which is always given horizontal members in erection.

The strength of the floor timbers should be designed for the full live and dead load, but any serious deflection will be caused only by the dead weight of the wet concrete. The full live and dead load can act together for a very short time only. Therefore I think that limiting the centering by such small deflections as Mr. Taft proposes and using full live and dead load is questionable practice. One place where deflection should be carefully guarded against is at the window head. At this point a slight deflection will cause much trouble and expense in setting the sash.

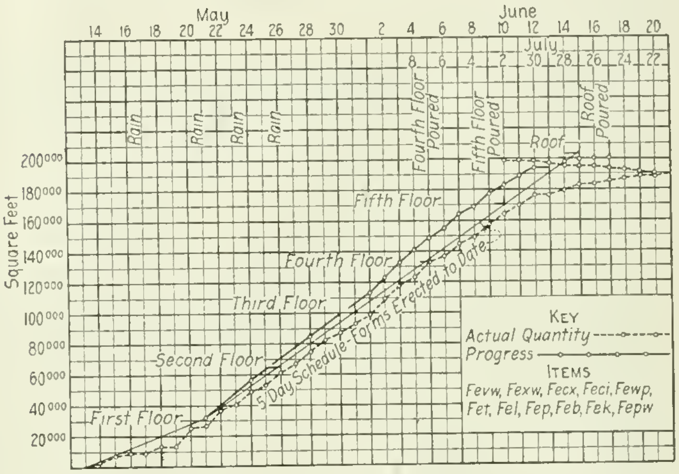


Fig. 1—Typical Form Progress Chart for Concrete Bridges.

The principal cause of settlement of form work is crushing of the soft spruce or pine lumber perpendicular to the grain in the girt over the post and also in the adjustment of the wedges under the posts as the full load is applied.

In this connection Professor Johnson, on page 468 of his "Materials of Construction," says: "Since timber is very weak in crushing across the grain, as compared to crushing endwise, this is found to be one of the most common methods of failure in practice. It is common to rest a timber column on a sill of the same wood and to design the column for its maximum working load, paying no attention to the utter inability of the sill to carry this load without crushing. Many failures of timber structures are due to this cause alone." An average safe value to use in form design for this crushing stress, as determined by numerous tests, is 400 lb. per square inch for spruce. Considering this stress, a 4x4-in. spruce post under a 4-in. wide girt is good for 6,400 lb. This is considerably less than the value of 16,800 lb. shown in Mr. Taft's table for an 8-ft. strut.

The trouble due to wedges can be almost entirely eliminated by using large hardwood wedges. If the posts are cut square at the ends to give an even bearing and heavy wedges are used to bring the posts to grade no settlement will occur.

Posts are usually placed on a plank sill. When these sills are laid on the ground great care is needed to avoid settlement because of deflection in the plank when a hollow place comes under the post. This often occurs when sills are placed on frozen ground and salamanders thaw out portions of the surface and thus cause soft places under the sills. When light sills are placed on a rough concrete floor deflection is liable to occur unless care is taken to give the sills an even bearing.

For these reasons I believe that limiting the floor timbers to very small deflections and at the same time using high loads on the posts is not consistent, and surely not economical.

---

*Paper, substantially in full, as presented before convention of American Concrete Institute, Chicago, Feb. 14-17, 1916.

The Design.

The first thing to be done in preparing a form design for a concrete structure is to make a careful analysis of the plans submitted by the engineer. This should be done as soon as the preliminary plans are available, for many details which seriously affect the progress and cost of the forms may be brought to the engineer's attention and changes made to the benefit of the owner. These points are often overlooked by the engineer, who does not always look at the structure from the construction point of view.

Factors Governing Design.—Chief among design factors is that of story heights. It is desirable that these heights be kept uniform throughout the building so that the column forms can be re-used from story to story without either cutting off or splicing. It is better to have the high stories at the bottom, as cutting off forms is much cheaper than splicing them.

Another important point is that of joints. I refer only to construction joints. These should be planned and the reinforcement detailed so that the forms can be erected in the simplest possible manner. These joints should, of course, come at a natural stop for a day's work and should be located so that they will least affect the appearance of the finished structure. The position and detail of any expansion joints should be determined early, as they will affect the form design and probably require special study.

An example of a detail to be considered in connection with the question of joints is the important one of making the dowels for the column rods long enough so that the necessary lap will come above the point where the column forms will actually start. It is not uncommon, for example, to find a wall beam, which comes above the slab, detailed so that it must be cast with the floor, and at the same time to find the lap for the column rods shown above the top of the slab instead of above the top of the wall beam as it should be.

It is economical to cast a curtain wall beam, used sometimes in mushroom construction, as a later operation. The forms can be made and erected more cheaply. This can easily be arranged for by providing pipe sleeves through the column to take the negative rods and a slot in the column as a seat for the beam.

The kind of windows must be decided upon at once so that the necessary groove strip can be scheduled and attached to the column sides and beam bottoms at the "making up" benches.

The floor finish will affect the form design. Questions as to the thickness of wood floor, or if granolithic, whether it is to be placed with the slab or as a separate operation, must be decided before the form design can proceed.

Steps in Form Design.—It is usual in the writer's work that excavation for the building begins at the same time the plans are started, or when the latter are in a very preliminary state. It is necessary then for the person in charge of the form design to be familiar with the structural design, so that points such as have been noted may be settled, the lumber bought, and the forms made up by the time the excavation is completed. When a complete set of plans is available the problem is easier.

The next step in the design is the preparation, by the cost department, of a progress diagram similar to that in Fig. 1. A description of the method of making the diagram is not within the scope of this paper. The limiting factor, however, is usually the date when the owner wishes the building turned over to him as part of his equipment. This diagram gives the dates on which the various floors must be completely formed in order that there will be time for the necessary "follow up" work. These dates will determine how many floors of new forms are necessary and when the design must be complete in order to allow sufficient time for making up and erecting. The number of men necessary to turn out the work in the drafting room in this time can also be estimated.

With this preliminary information at hand a conference is now held between the one in charge of the form design and the job and traveling superintendents. The latter are constantly in touch with the lumber market and are able to tell when the design must be governed by any unusual conditions. The sizes and lengths of lumber stocked in different localities vary considerably, and it is always desirable to make up a design of sizes that can be obtained at the lowest cost, in the required time, and in the necessary quantity. Delays because of non-delivery of the lumber are costly.

Another point to be settled is the part of the job where construction will begin. This matter is usually governed by field conditions and must be decided by the superintendent in charge after his study at the site. The movement of the forms throughout the job is dependent upon where erection is to begin, and therefore it must be known early.

The size, kind, and location of the concrete plant has some effect upon the form design and should be discussed at this conference. The capacity of the plant will determine a day's concrete work and will affect the location of construction joints. The speed of the work is also sometimes dependent upon the concrete plant.

At this time the general scheme of the form design can be discussed and any suggestions from the experience of the superintendents may be incorporated. If the job superintendent and his carpenter foreman are in sympathy with the scheme a better job will result from this team work.

Loads.—In calculating the sizes of form members we do not use a standard set of loadings, formulas, etc., for all cases, but treat each one separately, according to conditions. In general we use the following values:

Dead weight of concrete, per cubic foot, lb.	150
Construction live load on floor forms, per cubic foot, lb.	75
Pressure, per square foot, of concrete on columns and walls per foot of depth, lb.	140
Coefficient of elasticity for spruce or equal	1,200,000
Extreme fiber stress in spruce or equal:	
For timbers, per square inch, lb.	1,200
For column yokes, per square inch, lb.	1,800
Horizontal shear for spruce or equal, per square inch, lb.	200
Crushing perpendicular to grain in spruce or equal, per square inch, lb.	400

The proper value for the equivalent hydraulic pressure of concrete to use in form design has been variously estimated all the way from 75 lb. per square foot per foot of depth to twice that amount. The value of 140 lb., noted above, will give safe results and is based on actual experiments under job conditions. These columns were filled in a short space of time and the several mercury gages gave consistent readings of about 140 lb. per square foot, water equivalent.

With a slightly different arrangement of apparatus we have recently made three tests of concrete pressure on wall forms. Two of these were in a 20-in. wall, cast at the same time as the floor slab. The third was in a 6-in. partition wall, cast after the slab had been stripped.

The results of the first two tests seemed to indicate that the maximum pressure came when the head was about three feet and that it diminished or remained constant thereafter. This was because the wall could not be poured faster than 3 ft. in height in 30 minutes, and the concrete rapidly lost some of its hydraulic effect after this time had elapsed. Up to the time the mercury column began to fall the pressure was about 130 lb., but the head was so small the readings were unreliable.

The test on the partition wall gave good results, which averaged 125 lb. per square foot. This wall was filled in about 25 minutes. In this test also the gages showed a decrease in pressure after about 30 minutes.

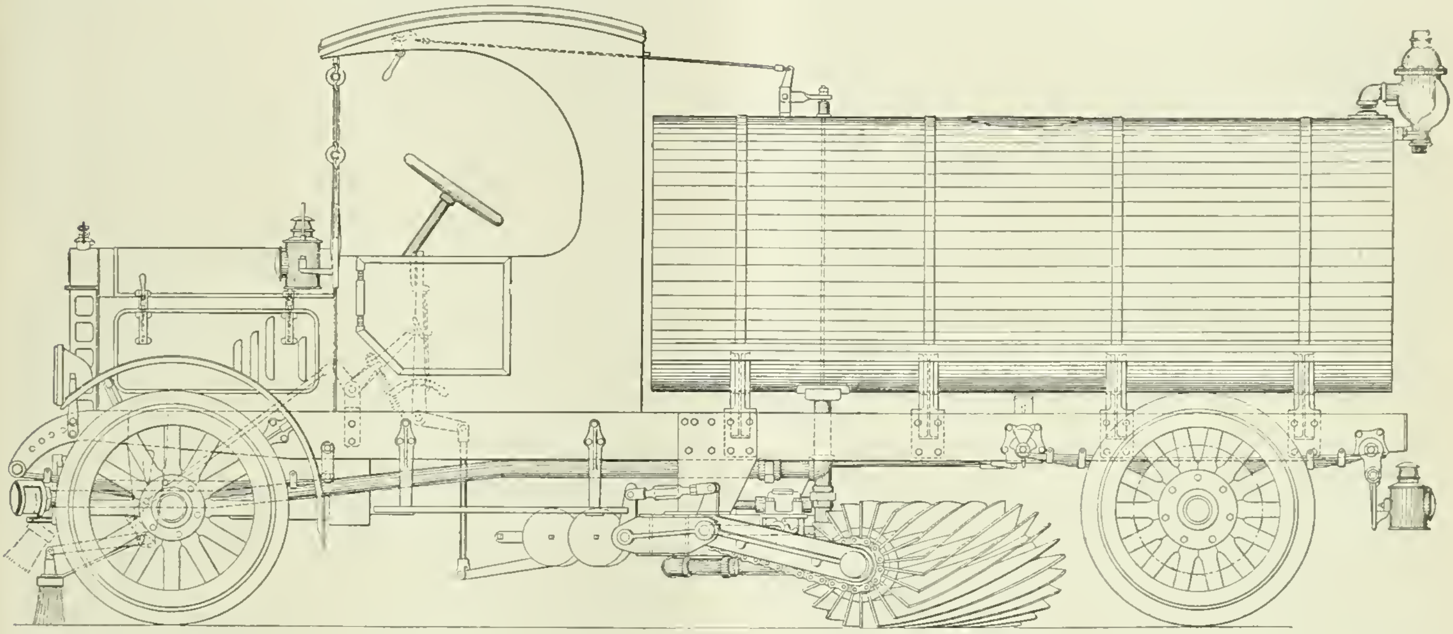
It would seem, therefore, that 140 lb. per square foot is a conservative value and further that the rate of filling the form should be considered in selecting the design head.

(To be continued.)

MOTOR DRIVEN SQUEEGEE FOR STREET CLEANING.

The Kindling rubber rotary squeegee of familiar use on horse drawn tank wagons is shown by the accompanying cut combined with a Sterling chassis carrying a 1,000-gal. tank. The essential features of the motor squeegee are described as follows:

Placed immediately in front of the front fenders of the chassis are two flusher nozzles controlled by the driver by a lever from his seat. The flusher nozzles by sprinkling the surface of the street prevent the agitation of dust, and also dampen the attached matter so that the squeegee roller can easily force it loose from the pavement and wash the surface clean. Supplementing the function of the nozzles in loosening the attached matter and to prevent the squeegee from being compelled to handle too large a mass of material, a pair of heavy pavement sweeping brooms are fitted immediately behind the front nozzles, the purpose of which is to force aside the large refuse so that it will become suspended in the water, leaving the squeegee to wash up the tightly adhered material by frictional action. Mounted near the center of the chassis frame and immediately underneath is a squeegee or spiral-shaped roller of 19 in. diameter and 8 ft. long. Each individual, specially treated rubber spiral is firmly but easily detachable, and mounted in a special kiln-dried wood holder of large wearing surface. And, being adjustable as they wear, more fresh surface of the squeegee can be brought into engagement with the street. The squeegee attachment is flexibly mounted and counterbalanced in such a way that when adjusted to a certain pressure it is impossible for the roller to work loose and the pressure against the surface of the street is uniform, the rubber strips being 6 in. deep, affording large wearing surface. A toggle joint linkage terminating in a lever in the driver's cab enables him to easily and quickly place the squeegee attachment in and out of engagement with the street; and when returning from washing a section of street to lift the roller out of contact with the pavement.



Sterling-Kirdling Motor Driven Squeegee for Street Cleaning.

The tank is fitted with a water meter which indicates the amount of water flowing through it. The water meter serves not only as a safeguard against the squeegee operator's idling and claiming to have squeegeed more street surface than he has, but gives data for calculating the water consumption per square yard for different kinds of pavements, under different conditions, etc. The tank contains four valves near the front end for distributing water to the front and to the side nozzles near the squeegee roller.

Based on tests made by the Municipal Research Bureau of Milwaukee, Wis., the following summary is furnished, comparing costs of horse-drawn and motor-driven squeegee street cleaning:

Average square yards cleaned per day	80,000
Cost per 1,000 sq. yd., ct	16.5
The assessment per front foot based on a street 30 feet wide and cleaned 50 times a season would be	1.37

The cost data show the operating expense of the horse-drawn and the motor-driven squeegees, and that the latter type will perform twice the amount of work of the former at a reduced unit cost.

A careful analysis of the traffic condition of the streets cleaned by squeegees shows that 1,105,324 sq. yd. are subject to this process of cleaning and that from the total yardage the amount of

413,825 sq. yd. should be cleaned 6 times,
308,133 sq. yd. should be cleaned 3 times, and
385,365 sq. yd. should be cleaned 2 times

each week, or a daily cleaning of approximately 700,000 sq. yd.

The average yardage covered per day by a horse-drawn machine being 35,000 sq. yd., it will require 20 machines, or an additional 8 over the present equipment, to perform the work; but if the motor-driven type were substituted the purchase of only four machines would be necessary.

The difference in operating cost of the two types would be as follows:

Horse-drawn type, average cost per 1,000 sq. yd., ct	25.5
Motor-driven type, average cost per 1,000 sq. yd., ct	16.5
Reduction in cost per 1,000 sq. yd., ct	9

If the motor-driven squeegees were not available, the cost of operating the eight additional horse-drawn machines would be greatly in advance of the motor-driven type, as the following data shows:

8 machines × $9.635 cost per machine = $77.08 × 150 days = $11,562.

By operating these 8 machines it would eliminate the service of—

9 white wings at $2 per day × 150 days	$ 2,700.00
8 sprinklers at $6.34 per day × 150 days	7,608.00
Total	$10,308.00
*Twice weekly squeegee cleaning	3,854.00
Grand total	$14,262.00
Less the cost of operating 8 squeegees	11,562.00
Effecting a season's saving of	$ 2,700.00

4 motor-driven machines × $13.26 cost per machine × 150 days = $7,956.

Saving over cost of operating 8 horse-drawn machines = $11,562 — $7,956, or a saving of $3,606.

With the same services eliminated for the motor-driven as for the horse-drawn squeegee, the total saving would be

$11,262 — $7,956 = $6,306.

*This item is included because certain streets are only cleaned twice a week that require the service six times weekly; and if performed the maximum number of times would eliminate the stipulated number of white wings and sprinklers.

The manufacturers of the motor squeegee described are the Sterling Motor Truck Co., Milwaukee, Wis.

LABOR COSTS OF PREPARING AND SEEDING A SMALL PARK.

Contributed by H. R. Ferriss, 203 Times Block, Victoria, B. C.

Following are labor costs of preparing and planting to grass a small, irregular park containing 1,440 sq. yd.:

		Cost per 10 sq. yd.	
Ploughing: Team and driver, 4 hr. at 70 ct	$ 2.80	$0.194	
Harrowing: Team and driver, 8 hr. at 70 ct	5.60	0.390	$0.584
Raking: Labor, 130 hr. at 20 ct	$26.00	$1.806	
Seeding: Labor, 30 hr. at 20 ct	6.00	.417	
Remove screenings: 8 hr. at 20 ct	1.60	.111	$2.334

All grading and rough leveling had been finished before the park was plowed. The soil was a light loam thickly sprinkled with small stones. The ground was first plowed with a light farm plow and then thoroughly harrowed with a spike-tooth harrow. The area was raked twice before seeding; the first raking gathered up the stones and clods into convenient piles, and leveled the ground. These were removed with a wheel-barrow and the area then rapidly gone over with a fine rake. Three men were engaged in seeding, which was spread by hand and worked in with a fine rake.

MUNICIPAL COST DATA, METHODS OF RECORDING AND VALUE.*

By Karl M. Mitchell, City Manager, Sherman, Texas.

The function of accounting is to report and to analyze business transactions. The characteristic of a good accounting system is that it gives to the administrative officers the information necessary for them to know the results of past performance, and from which they may form correct judgments as to future methods and activities.

There are several things that the efficient executive must know.

Capital Outlay and Expense.—First of all he wants his expenditures divided into capital outlay, maintenance and operating expense. Capital outlay will include those long-life improvements usually paid from bonds, such as pavements, sewers, etc., and also those items of comparatively long life, usually paid from current revenues, such as office equipment, machinery, tools, instruments, horse and motor vehicles, etc.

This division is absolutely essential if an intelligent comparison is to be made between the expense of one year or period, with another year or period. It is manifestly better management to spend $100,000 divided $30,000 for equipment, tools, etc., and $70,000 labor and supplies than to spend $10,000 for equipment, and $90,000 for labor and supplies, assuming that the equipment is wisely purchased and will result in future improved service or decreased expense, or both. And it is easily demonstrated that circumstances may arise in which an expenditure of $125,000 might be better management than an expenditure of $100,000, provided the additional expense was all for capital outlay, and would result in improved service and lower unit costs over a period of years.

Functional Cost.—The second thing that the efficient executive wants to know is the cost by function or activity. It is essential that the entire cost of street pavement for instance be collected in one account. If the payments paid the contractor be carried in one account, the engineer's labor and expense be carried in another, if the inspector be carried under a third, and a portion of the work be done directly by the city and charged to a fourth, the true cost of the pavement cannot readily be determined.

Cost by Object Purchased.—The third thing wanted is that the cost of each function be segregated by cost of object purchased, such as labor, supplies, etc. The cost of operating the water works plant as indicated by functional accounting may be high, or low, but a further analysis will be necessary if the cause is to be located. If for instance the fuel cost be found to be high, the search for the cause will be narrowed.

Unit Costs.—The fourth cost that the efficient executive wants is the unit cost. In the example just given he wants to know not only the cost of fuel for pumping water, but the cost per 1,000 gal., or unit quantity pumped. Comparison of unit costs is one of the most effective methods of determining and developing administrative efficiency.

Data Records.—The determination of unit costs involves not only the amount of money spent for each item or operation but also the quantity of work done. For instance in the example referred to, to determine the cost of pumping per 1,000 gal. requires both the cost of pumping and the quantity pumped.

Cost Units.—The determination of cost units and the extent to which they will be used, is a subject largely for the individual skill of the manager and his subordinate and advisers, and should be worked out with particular objects in mind.

No broad rule may be adopted adaptable to all cities under all conditions. Where public utilities such as water works or light plants are operated by the municipality the cost units may well be those of similar private owned utilities, which have now become well standardized.

The larger organization will require more minute units than will the smaller organization. In fact for some of the smallest cities the classifications outlay and expense, function, and object may be sufficient, as the executive is usually in so close touch with his work that unit costs may be dispensed with, or else collected irregularly as need requires.

Methods.—The primary means for collecting the necessary physical and operating data, and distributing expense items is usually a work order, a time report, and a data report.

Every important or extraordinary job should be covered by a separate work order. Work of any ordinary or routine nature such as policemen, firemen and operating engineers on regular duty, clerical work, etc., may be covered by a subdivision in the functional account, and no job order be required.

Time reports showing detailed classification should be required daily of men working on a variety of work, and at less frequent periods, every week, or semi-monthly, from employees who have but one duty, such as water collector, stenographer, etc.

Data reports should be received at intervals dependent upon the character of the data, how obtained, and the period with which cost reports are desired by the executive, and the size of the organization.

In a small city a weekly report is usually sufficient from such departments as the Health, or Law, while in the larger cities daily reports may be warranted.

The work orders, time and data reports should be designed to facilitate original entries, and compilation therefrom, and bring the essentials together so that a ready analysis may be made.

An accounting system which provides these four kinds of information has the basis for a good system, but is practically of small value unless the information is properly reported.

The essentials of a good report beyond the requisite accuracy and completeness is that it be presented to the executive, regularly, as frequently as practicable, and as promptly as possible after the close of each report period. It is vital also that the report be presented in such manner that the reader may get clear impressions of the facts presented, and may make ready comparisons with previous periods.

In fact an enlightening comparison is usually the most valuable part of such a report. The cost of performing a given function has little meaning by itself. It is only by mentally or visually comparing the cost with the cost of similar work at some other time or place that we form a conception as to the efficiency attained.

The important comparisons should be presented so as to be quickly grasped by a busy mind with many distracting influences.

The most valuable comparisons are usually with previous performance by the same city. A good form of functional and unit cost report is to show in six columns the total cost this month, the unit cost this month, the increase or decrease in unit cost over last month, the accumulated unit costs this year to date, the increase or decrease in accumulated unit costs over last year to date, in money, and in percentages.

Typography is an important feature of a good report and must not be neglected if it is to serve its purpose well. Style of headings, indentations, spacings, groupings, use of capitals, etc., are necessary to a clear impression of the facts to be brought out.

Charts.—Better than the typed report in many instances is the graphic chart. They may be made to show the trend of events over a considerable period of time, and enable one at a glance to grasp the relation of the present to the past, and to indicate what may be expected in the future.

Simplicity.—In devising and installing a cost accounting system, due regard must be given to the cost of operating the system. The function of a municipality is to provide pavements, walks, sewers, lights, water, etc. And an accounting system has a legitimate place in the municipal organization only in so far as it aids in the efficient and economical performance of these functions.

---

*Paper before annual convention of City Manager s Association.

Professional accountants sometimes overlook this fact and in their enthusiasm for their calling may build up a tremendously perfect accounting machine but one which in its operation leaves little time for the employee to engage in productive work. Care must be exercised to see that the accounting system is as simple as possible and not overloaded with useless checks and non-essentials. While recognizing the necessity of a check, the chief value of a good system lies in the control which it gives to the executive over production and operating costs.

Analysis.—An accounting system perfectly adapted and reported is of uncertain value if the executive is not able to analyze the report, read to a certain extent between the lines, give mental consideration to invisible and changing factors and make correct judgments therefrom which will correctly determine his work for the ensuing period. To permit such analysis the executive for whose use the system is designed must be familiar with its operation and must know the exact basis for classification, and the actual disposition of uncertain items. To this end there should be definite rules for classification along lines heretofore indicated, and every voucher should bear its classification in full, from which no deviation should be made after it has been signed by the executive.

Value of Cost Accounting.—A properly conceived and well designed system of reports, giving currently and promptly to the executive information on every essential detail of the business for which he is responsible, is one of the chief factors in effective organization and successful management. The larger the organization, the more necessary such reports become, as it is impossible for the administrator of a large organization to maintain personal contact with each employee and each job being done. It is in fact undesirable that he should do so, for in the attempt he will find himself overwhelmed with minutae, incapacitated for viewing the business in its true perspective, and deprived of the time necessary for future planning.

With all essentials concentrated daily at his desk by means of properly devised reports, the executive may review a day's operation in a few minutes and obtain a comprehensive grasp of what is being done. Unusual or abnormal conditions are quickly revealed, permitting him to concentrate on things that require investigation and action. With time conserved through not having to give his attention to details and to matters which according to the reports require no attention, the executive will find time for the study and planning which are so essential to successful management.

The prime duty of an executive is to organize, and plan. Details should be left to subordinates. A maxim of the successful administrator is "Organize, Deputize, and Supervise."

Ample and accurate information, as one of our railway kings has said, is the first step toward success, and the better the executive the more anxious he is for such information as will aid him in the formulation of judgments and serve as a guide for the future. To secure such information he must analyze his organization and its problems, determine what information he needs, devise or adopt a system of recording the data desired, install it, and then see that it operates smoothly and regularly so as to bring to him the information he requires.

Comparative Cost Records.—The chief value of any cost accounting system lies in the comparisons it offers with previous performances of the same city. Facts are always informing, but it is only when they are compared with those of other periods and the increase or decrease noted that there arises the maximum of questions to the executive. It is by having the record day by day, week by week, month by month, or year by year, that the significance of current results is emphasized; wastes and inefficiencies detected, service failures noted and improvements suggested.

Uniform Cost Record.—Municipal accounting is really a new science. It is hardly a decade since modern accounting was first applied to a municipality. That there is now a demand for a specialized cost accounting is evidence of the remarkable change in civic standards in the last decade, and an indication of the progress of the cities. One result which it is desired to obtain by the development of unit costs is that the cost in one city may be compared with that of another.

Such an ideal is most desirable though in practice is difficult to attain. For instance many factors enter into street cleaning, such as, the kind of pavement (macadam, asphalt, etc.), the kind of traffic (horse drawn or motor), the amount of traffic (per foot width of pavement), the grade of the pavement and the facilities for removing storm water from pavements (which determine in a measure the scouring effect of rains), the frequency of scouring rains, the character of adjacent streets (particularly whether paved or not), the kind of street cleaning equipment used, and the disposition of cleanings, and length of haul.

While these factors vary as between streets in the same city, the conditions are liable to remain fairly constant for the city as a whole, while as between different cities there is a wide variance.

Were a uniform scheme of cost units adopted by name there is still the difficulty of getting cities to give them uniform interpretation, and thus make the units in fact uniform.

A table recently published stating the cost of street cleaning per 1,000 sq. yds. to be 26 ct. in Chicago, 67 ct. in Philadelphia and $1.28 in Boston, means little. Here we have a fairly well standardized cost unit, but due in part to varying interpretation and the degree of care used in collecting data and in part to inherent local condition, there is a wide variance.

In a considerable measure the advantages arising from comparative costs for different cities may be secured by a standardized classification for general and functional accounting. This is an easier step, and may be considered preliminary to the standardization of cost units. Functional costs, based on a standardized system and reduced perhaps to some simple unit such as per capita, would be of much value in comparing the extent of the activities and administrative efficiency of one city with another. The first step then is the adoption by interested cities of a uniform accounting system.

COST OF CUTTING GRASS ON BOULEVARDS DURING JULY AND AUGUST.

Contributed by H. R. Ferriss, 203 Times Block, Victoria, B. C.

Following are the costs of cutting grass on boulevards in Victoria, B. C., during July and August of 1914. These months were hot and dry—no rain falling at any time:

	Cutting				
Date.	Hand.	Horse.	Repairs to mowers.	Total cost.	Cost per 1,000 sq. yd.
July 1-15	$37.00	$60.60	$3.60	$101.20	$0.843
July 16-31	34.55	45.35	9.70	89.60	0.746
Aug. 1-15	25.10	40.20	9.15	74.46	0.620
Aug. 16-31	24.00	38.55	1.40	63.95	0.533

The above costs are the net labor costs for cutting grass only. They do not include any other labor, such as trimming the edges of lawns, weeding, etc. The repairs include sharpening and replacing broken parts. The rate paid was 45 ct. per hour for horse and driver, and 17 ct. for hand labor. The grass was cut on an average of every five days.

The total area cut comprises 120,000 sq. yd., and is made up of long, narrow boulevards intersected at frequent intervals by street crossings and private driveways, and with many obstructions, such as light standards, fire hydrants, etc.

In cutting, a 32-in. horse mower was sent ahead, cutting all the areas which could be readily reached by it. The hand mower followed and cut all areas inaccessible to the horse mower, the edges of walks, etc. The grass was caught in specially designed catchers and dumped on the pavement to be picked up later.

The higher costs in July are due to a certain laziness on the part of the driver when he dumped the grass and to a horse that walked slowly. The first of August both horse and driver were changed, with the result shown.

FURTHER COMMENT ON A CO-OPERATIVE ORGANIZATION OF ENGINEERS.

To the Editors: In reply to the editorial, entitled, "A Quotation, Some Questions and a Request," published in your issue of Jan. 12, 1916, permit me to offer the following comment:

The ethics of the people of the United States are opposed to armies, battleships, guns and other engines for the destruction of life and property, yet because of conditions existing in other nations it is considered practical that we have sufficient armament to maintain the dignity and standing of the nation and to protect its people. Preparedness for the nation requires many trained men, much armament and equipment, and money.

Preparedness for the engineer who is to acquire and maintain a dignified standing in a community requires education, ability, training and an ample income. He may not excel in any of these qualifications, but if he is seriously lacking in the latter the practical, commercial and social ethics of the community would not rate him as a man of standing no matter how learned or experienced he might be.

The composite opinion of the people as to the relative importance of the engineering profession as compared to other professions is the true and practical measure of its standing in the final analysis. While the courts recognize engineering as a profession, and the statute books prescribe duties, procedures and compensations for engineers on public works, it is the people as a whole who assign to the profession whatever standing it may have, which determination is largely based on the standing of men composing the profession. To have standing in a community, as we generally accept the term, a man must possess certain cardinal virtues, must have such ability and learning as will enable him to associate on equal terms with the leading people of the community. He must participate in some public and semi-public activities, such as charities, civic and commercial organizations, and last, but not least, when measured by our present day commercial standards, he must be at least moderately successful in a financial way so that he may maintain his standing on an equal basis with other successful business and professional men.

Municipalities, state and county road departments, industries, and the railroads employ most of the engineers, and in this county during the past ten years an unusual number have been employed on such work. This county (Lake County, Indiana) has a population of over 100,000, including three cities of more than 25,000 population each. In ten years more than one hundred millions of dollars have been expended by corporations and railroads in the county and probably ten millions by the county and by municipalities for public works.

The maximum salary allowed by statute in cities of this class is $1,500 per year for city engineers, while the county surveyor and engineer is allowed $2.50 per day for preliminary work on road construction, that is, determining line and grade, making plans and specifications for the road, including necessary culverts, bridges, drainage, etc. For construction he is allowed $3.50 per day and his assistants and inspectors $2.00, and for drainage the scale is $4.00 and $2.00, respectively. The legislature also provided that where the county surveyor was not a competent engineer, the commissioners might employ a "competent civil engineer" to carry on the work, the rates of pay to be as above stated. The county surveyor has the right to appeal to the courts of the county to prove his competency in such a case, however. The statutes thus plainly set forth the value of a "competent civil engineer's" services, and the courts are empowered to define the term.

The scale paid by industrial corporations and railroads is about the same as that on public work.

While the rates of pay have been moderate the writer knows that there has never been a shortage of engineers at any time during the period referred to. As to a private practice in the community, the field is not profitable unless contracts other than strictly engineering work are engaged in, as those holding other positions do more or less private work in order to increase their income.

Summing up the situation as applied to this community, which has done so much engineering work in the past ten years, I would say that such work does not offer opportunities for engineers to obtain any great standing because the limited income in any branch of the work would not permit them to follow such inclinations as might lead to obtaining and maintaining a standing on equal terms with successful lawyers, physicians and business men. The nature of the work is such that very few can establish offices and carry on an independent practice, so the great number must be salaried men. They are of course equal in education to other college men, but for the reasons given they do not have opportunities to develop and obtain standing.

If engineering service is rated at its full value, discussion is out of order; if not, the remedy must originate from within the profession—any policy of assuming lofty and noble principles and waiting for the public to recognize and reward unselfish service will not avail. If the engineer applies business methods to other people's affairs he must do the same with his own. If he has worked two years preparing for college, spent four years and two thousand dollars in college, and six more years at a nominal salary getting experience, and is rated as a good average engineer, he might then apply the principles used in valuing public utilities and determine his own value and the value of his services. The statutes of the State of Indiana fix his rate at $2.50 per day in case he is engaged in the preliminary work of laying out, designing, and preparing plans and specifications for highways and appurtenances thereto—possibly the engineer would make a different finding.

The profession could not, without becoming a labor union establish and maintain arbitrary rates and salaries, yet moral obligations and a sense of loyalty to the profession might be promoted to the end that engineers, whether employers or employes would, so far as possible, conform to some standard.

A frank attitude toward the thousands of bright and ambitious young men who graduate annually should be cultivated, so that they might know the probable percentage of their number who might become successful engineers, impressing on them the fact that there are not positions waiting for any considerable number, as they must soon discover, and that their education is a valuable asset in any line, whether it be farming, mercantile or manufacturing. With such an attitude they need not flounder around until disheartened, letting opportunities pass because the work is not engineering.

Proper ethics, dignity, efficiency and standing for the profession can not be built up until the weak point, the matter of compensation, is greatly improved.

If it is possible to get any of the existing organizations to take up this question, a separate organization would be superfluous—we have too many dues and overlapping organizations now.

My suggestion would be that some state society father such a movement and lay out a plan of procedure, somewhat as follows: First, make some logical determination of the value of engineering service under various conditions. (The American Society of Civil Engineers has compiled statistics as to the incomes of its members, taking into consideration many different conditions). Second, have a special legislative committee on the subject of compensation, so that the society may be informed as to contemplated legislation, that the legislature may know the wishes of the society, and that each individual engineer may be instructed to take up the matter in person with his local representative. Third, have those who can write well and get a hearing in the local or metropolitan press use this channel in a dignified manner, and have those who can talk well make use of opportunities before commercial and civic organizations. Fourth, advocate some rule as to the employment of those who intend to follow engineering only as members of field parties and as inspectors, especially emphasizing the fact that these positions can not be filled by indifferent political hangers-on. Fifth, get in touch with all other state and national engineering societies and clubs in an endeavor to have them take up the question and co-operate so far as is possible.

I believe this movement could originate better in a state society for the reason that conditions differ so much in different states that one plan would be unsuited to all, also that state societies could be better represented at meetings and could get in closer touch with the legislature and the people. Of course legislation would reach directly only those employed on public work, but on account of their great number it would indirectly affect all by establishing precedents. Publicity work would be more general in effect because it would educate the people. Putting an honest value on products or services is not mercenary or undignified—it is following custom and business methods and meeting conditions as they exist. Employing only those who are or expect to be engineers on engineering work is both business-like and professional.

References to money matters are not unethical but are very practical. The tape measure used by an employer in determining the value of services is graduated into dollar marks and hundredths, and if an engineer can be hired cheaper than a bricklayer the employer does not question whose services are worth most—he reads it direct from his tape measure.

Very truly yours,
A. P. MELTON.

Gary, Ind., Feb. 4, 1915.

A DEFENSE OF THE INFILTRATION GALLERY.*

By Alexander Potter, Consulting Engineer, New York City.

The procuring of water supplies by means of infiltration galleries is not common. Even where the use of infiltration galleries promises to yield good results, engineers often hesitate to make use of them because of the many failures recorded, the causes for which either are not understood or when understood have not been brought to the attention of the engineering profession.

The proper design of an infiltration gallery should not be at all difficult, for the process which takes place in an infiltration gallery is duplicated in nature by the diffused seepage of the underground waters into surface streams. This ground-water seepage maintains the flow in surface streams long after the direct effects of the rainfall have ceased. The fundamental laws governing the ground-water flow of surface streams are fairly well understood and apply with slight modifications to infiltration galleries. They may be stated as follows:

1. The ground-water stream flow is fixed and limited to the surplus underground waters accumulating and stored in the valley.
2. The rate of seepage varies with the transverse hydraulic slope of the ground-water table and the porosity of the material through which the ground water flows.
3. When the hydraulic slope is not steep enough to discharge the surplus ground waters as fast as they collect in the valley, the ground-water table rises until equilibrium is established, and vice versa if opposite conditions exist.
4. Except as affected by the seasonal changes of the rising and lowering of the ground-water level, the ground-water stream flow is constant.

There is no reason why the seepage of ground water into an infiltration gallery under proper conditions should not be equally as dependable as the identical natural process of ground-water seepage into surface streams.

An infiltration gallery may derive its supply of water from two distinct sources: A supply derived by intercepting the surface underground waters which were under natural conditions joining the surface waters by diffused seepage, and a supply derived by infiltration from bodies of surface waters adjacent to the infiltration gallery. It appears that many infiltration galleries derive by far the larger portion of their supply from the second source. A carefully made scientific investigation will in nearly every case reveal within quite narrow limits the quantity of water available for an infiltration gallery from the two sources above mentioned, and as long as the draft does not exceed the available supply there is no reason why the yield of a properly designed infiltration gallery should gradually decrease with time, as is only too often the case. The recorded failures of infiltration galleries can, in the writer's opinion, be largely attributed to the erroneous assumption that a pipe laid below water level with open joints or perforations and surrounded by a porous material will continue to deliver the volume of flow developed when first constructed, ignoring entirely the fundamental law of supply and demand.

This is not true with infiltration galleries constructed on the floor of an impervious strata intercepting the transverse ground-water flow in a pervious strata of coarse sand immediately above. Under such conditions, infiltration galleries have been very successful. A typical example of such a gallery is the one constructed at Munich, Germany.

Under conditions other than that just stated, and where the supply appears to be adequate, there is often noted a gradual breaking down of the infiltration gallery, apparently due to the silting up of the filter media immediately surrounding the gallery. Under the natural conditions of ground-water seepage into surface streams, no such silting appears to take place, and when such silting up occurs in connection with an infiltration gallery, it can only be due to the peculiar ground-water conditions set up by construction of the gallery. The writer believes that the silting phenomena are primarily due to the high velocities of the ground water through the filter media immediately adjacent to the gallery, velocities so great that the finer particles of soil are transported to the gallery, gradually clogging the interstices in the filtering media and the gallery proper. This phenomenon of clogging is aggravated by the lowering of the ground-water level in the vicinity of the filter gallery below the top of the gallery. For a definite yield, as the wetted perimeter of the gallery decreases, the entrance velocity increases in inverse proportion. To attempt, therefore, to force an infiltration gallery to the extent of lowering the ground-water table below the top of the gallery, will tend to increase the danger from clogging and materially shorten the life of the infiltration gallery, especially when constructed in the finer sands.

With tubular wells, the question of high entrance velocity in the filtering media surrounding the well screen is not of equal importance; wells are comparatively short-lived, and when clogging does occur it can be remedied by back-flushing or other known methods. No such remedies are available for clogged infiltration galleries. When properly designed so that the yield of the gallery does not exceed the supply available from the surplus underground waters and the supply derived by infiltration from a nearby body of surface water, and the entrance velocities are sufficiently low so as not to transport the finest soil particle, the useful life of the infiltration gallery should be practically unlimited.

The yield from an infiltration gallery constructed in the finer sands should be automatically controlled so that it cannot exceed a certain predetermined amount, in order to prevent the lowering of the ground-water plane below the top of the gallery, so as to keep the entrance velocities within safe limits. This condition can best be secured by restricting the flow from the gallery to an amount which will keep the gallery constantly full of water for its entire length.

In many cases the requirements as outlined herein will for a given yield call for the construction of much longer lines of infiltration galleries, constructed in finer sands than has been the practice in the past, so that in many instances other methods of supply will be found to be more economical. Throughout the country, however, deposits of gravel and sand exist in the valleys of rivers and along lakes and seacoasts, in which infiltration galleries can be economically constructed to yield adequate supplies either from the surplus underground waters or from the water derived by infiltration from adjacent natural and artificial bodies of water, or from both sources. The successful results on Long Island show the maximum possibility of such a supply.

---

*From a discussion printed in the Journal of the New England Water Works Association for December, 1915.

In tropical countries, where there exists so strong a prejudice against the use of stored surface water for a public water supply, due to the deterioration resulting from the luxuriant vegetable growth abounding in such waters, the use of an infiltration gallery is often advisable. The natural purification which takes place in the water while passing from the surface reservoir to the infiltration gallery has been found to be effective. The ability economically to produce a good, clean potable supply even from a very inferior raw water by double filtration, or by other methods, has not been generally recognized. It appears that ground waters are largely preferred, and the proper use of infiltration galleries alone or as a supplement to a well supply is an important matter.

COST OF PROVISION FOR TRAFFIC DURING ROAD CONSTRUCTION.*

The provision necessary for caring for traffic during construction is dependent upon the nature and the amount of such traffic. For roads in a farming community the maximum traffic usually occurs during the time when grain is being hauled to market, and can possibly be provided for by a temporary roadway alongside of the new construction or through adjacent fields. Under other conditions many factors tend to complicate this problem. For example, on a road adjacent to a fairground considerable expense will probably be entailed in making adequate provision for traffic such as will occur when the fair is in progress. A detour through adjacent fields which would be entirely adequate for ordinary hauling will prove entirely inadequate for congested motor traffic. Every main highway or tourist road constitutes a special problem, and a traffic provision suited to local needs must be provided in each case. For these reasons traffic conditions must be taken into account in preparing an estimate.

The season of the year during which the road is to be constructed will also affect the cost of caring for traffic. The construction of a farm road which will be only partly completed late in the fall will entail the additional expense of placing the road in condition so that winter hauling can be carried on at minimum inconvenience, and also with minimum harm to the unfinished roadway. Obviously, the weather conditions during the time when traffic must be provided for will greatly affect the cost of that item.

These and many other conditions emphasize the fact that no accurate estimate of this item of the cost can be made only when the approximate time of year during which the construction will be carried on is known beforehand. The time set for beginning the work and the estimated rate of progress will indicate the period during which construction will be under way.

Local weather conditions and the character of the subsoil have much to do with the possible date of starting construction. From residents along the right-of-way information concerning the state of the road in spring and early summer can be obtained, from which may be determined, with reasonable accuracy, the probable date upon which it will be practicable to start construction.

The character of the topography and of the vegetation on adjacent land sometimes influences to a considerable extent the rapidity with which a road will dry out in the spring. For example, a roadway passing through a dense forest growth will probably be wet and muddy at a much later date than one which is so situated as to get the full benefit of the sunshine. It may be necessary to resort to dragging and draining a part or all of the road to be improved, in order to place it in condition to commence construction work. The cost of dragging and surface draining will usually vary from $5 to $10 per mile, but may amount to much more. Small items of cost such as these may seem trivial in comparison with the cost of the finished work, but collectively may represent the difference between profit and loss.

The routes for detouring traffic during construction also vary with the locality, and may modify to a considerable extent the cost of construction. In prairie states, the highways, in general, follow section lines and the maximum detour will not be more than two or three miles, but in a hilly country, where a road is located in a valley or on the side of a hill, the problem is not so simple. Here it may be the part of economy to change the detail or section of the road considerably, placing the concrete road against the upper slope with a gutter along the edge, and putting the full width of shoulder along the lower side—this wide shoulder serving also as an earth track during construction. A change in detail of this kind must be taken into account and provided for before construction commences.

---

*Extract from Special Committee Report Second National Conference on Concrete Road Building.

LEAGUE OF IOWA MUNICIPALITIES CALLS CONFERENCE TO CONTEST CLAIMS FOR PAYMENT OF ROYALTY FOR USE OF SEPTIC PROCESS OF SEWAGE TREATMENT.

To the Editors:—It has probably been called to your attention that the Cameron Septic Tank Co. is threatening to bring suit for royalties under its patents on the septic tank process against the different municipalities and others who have installed septic tanks.

A number of years ago this company brought suit against the City of Knoxville, Iowa, as a test case and a number of cities and towns of the middle west organized a defense league and carried the Knoxville case to the Supreme Court of the United States. The question in the Knoxville case hinged very largely on the expiration of the British patents and the Court held in that case that the British patents had expired. Recently the company has brought a case against the city of Winchester, Kentucky, under their American patents for the process and the Federal Court at Richmond, Kentucky, has recently held that these process patents are good. The city of Winchester evidently did not contest this case very strenuously or did not have the assistance of the best patent attorneys in the country. The company is now basing its claims on a decree rendered in that case and is claiming royalties and threatening suit against those having plants installed.

On account of the former association, that financed the fight in the Knoxville case, a great many cities and towns, many of those interested in the previous case, have written and suggested that a meeting be held to organize another defense league to fight the present claims of the company as to their patent of the septic tank process. I presume that these requests have come to the Iowa League very largely on account of the fact that the Knoxville case was an Iowa case and that we had a league at that time and secured the very best patent attorneys in the country to look after our interests.

In compliance with these requests the League of Iowa Municipalities has called a meeting at Des Moines, Ia., to be held at 10 a. m. on March 14 at the Savery Hotel, to consider this question and take such action as the delegates at that meeting may decide. All those interested in this question are invited to have representatives present at the meeting or if unable to be represented are invited to write the undersigned, giving the facts in regard to their situation.

The case against the city of Winchester does not settle the question but to protect its interests every municipality interested in these proposed suits should co-operate in contesting the claims for a royalty.

Very truly yours,
F. G. PIERCE,
Secretary League of Iowa Municipalities.
Marshalltown, Ia., Feb. 21, 1916.

COST AND TEST DATA ON PUMPING WATER WITH OIL ENGINES.*

By C. R. Knowles, General Foreman of Water Works, Illinois Central Railroad.

Internal combustion engines using gasoline as fuel have long been in use for railway water service. The increased consumption of water, necessitating larger pumps and heavier power, together with the increase in the cost of gasoline, has made it necessary to look to a cheaper fuel in the operation of water stations.

In order to utilize the existing equipment many of the gasoline engines now in service have been converted to kerosene and distillate engines by the addition of attachments for pre-heating the oil to or near the flashing point before the oil enters the cylinder. These attachments consist of generators or mixing chambers wherein the oil is heated by the exhaust of the engine. They are made in various sizes and types, both for throttling and for hit and miss governors. With these attachments the engine is generally started on gasoline and is allowed to run on this fuel until the cylinder and generator are heated, when the oil is cut in. On other types a retort is provided where the oil is converted into a vapor or gas by heating the retort with a blow torch. Either method requires from five to ten minutes to start an engine running on oil. Electric ignition is used, as with gasoline engines. Very little carbon trouble is experienced with the use of these attachments and the lubrication required is about the same as with a gasoline engine.

Test No. 1.—A series of tests as recorded in Table I, of various fuels was made, pumping a total head of 61 ft., with an 8x10-in. single cylinder double acting pump direct connected to a 6-HP. four-cycle horizontal gasoline engine equipped to run on kerosene and distillates as well as gasoline, controlled by a throttling governor. This engine was one of the first gasoline engines ever equipped to operate on low grade oils and has been continually operated on distillates from 36° to 42° Baume for the past six years.

TABLE 1.

Fuels used.			
Distillate	40°	Baumé	Flash, 150. Burn, 145.
Methyl alcohol	40.5°	Baumé	Flash and burn at room temperature
Kerosene	46°	Baumé	Flash, 124. Burn, 170.
Gasoline	62°	Baumé	Flash and burn at room temperature
Motor spirits	58°	Baumé	Flash and burn at room temperature

Efficiency Fuel Tests.

	Distillate.	Alcohol.	Kerosene.	Gasoline.	Motor spirits.
Pints per hour	6	7	6	7	6
Lb. fuel per hour	5.145	6.062	4.943	5.373	4.755
Lbz. fuel per HP.-hr.	1.91	2.22	1.91	1.97	1.74
Pump. rev. per min.	43.35	43.32	43.54	43.72	43.79
Pumped, gal. per min.	175.	177.8	176.8	176.8	178.1
Cost of fuel per gal.	$0.04625	$0.40	$0.08	$0.15	$0.13
Cost of fuel per hour	.0347	.35	.06	.1313	.0975
Cost of fuel per HP.-hr.	.0129	.1282	.0220	.0483	.0356
Cost per 1,000 gal.	.0033	.0327	.0056	.0124	.0092
	Deg.	Deg.	Deg.	Deg.	Deg.
Temperature of cylinder start	165	90	135	46	46
Temperature of cylinder run.	145	145	145	130	125
Temperature of inlet air	110	125	120	60	60

As will be seen from Table I the distillate is the most economical of the fuels used. The cost per water horsepower being 53 per cent of the cost of pumping with kerosene, and only 27 per cent of the cost of pumping with gasoline. The high cost of alcohol eliminates it as a fuel for pumping water and the result of the test is merely submitted as a comparative feature. No doubt better results could have been obtained by reducing the area of the combustion chamber as more compression is required to secure economical results from the use of alcohol in internal combustion engines. The power obtained from the use of kerosene was practically the same as from the distillate, the only difference being in the price of the two fuels. The gasoline test shows such results as might be obtained from the average gasoline engine under the same conditions. The fuel known as motor spirits, which has been widely advertised as a substitute for gasoline, operates under practically the same conditions as gasoline. An objectionable feature of this oil is a disagreeable odor and it would perhaps be undesirable to use in certain localities.

Test No. 2.—A 12-HP. four-cycle gasoline engine with a hit and miss governor pulling a 7½-in x 30-in. working barrel in a deep well was equipped with a generator for burning low grade oils. Comparative tests showed that the engine consumed the same amount of 39° distillate per horsepower hour as gasoline. The difference in the cost of two fuels, however, showed a saving of $.0434 per horsepower hour in the use of the distillate. The cost of pumping water at this point is comparatively high, due to the fact that the water is pumped with a single acting deep well cylinder.

The results obtained are given in Table II.

TABLE II.

	Gasoline.	Distillate.
Pints per hour	14	14
Lb. of fuel per hour	11.746	12.005
Lb. fuel per HP.-hr.	3,458	3.53
Pump, rev. per min.	24	24
Pumped gal. per min.	124	124
Cost fuel per gal.	.125	.04625
Cost of fuel per hour	21,875	8.093
Cost fuel per HP.-hr.	.0643	.0209
Cost per 100 gal. water	.029	.0108

The heavy oil engine is a comparatively recent development and is being extensively used in railway water stations, as well as for other service. The most popular engine of this type is the two-cycle oil engine constructed in units of 50 HP. and under, using heavy oil as fuel. This type of engine is very often confused with high compression engines operating on the Diesel principle or with the converted gasoline engine using kerosene and distillates through a carburetor or mixing valve.

The cycle of operation of the Diesel engine is to compress air to 450 or 500 lbs. per square inch, generating a temperature of approximately 540° C. Into this highly heated air the fuel is injected during the return, or second, stroke of the piston in a finely atomized form at such a rate as will maintain a constant temperature while burning and in such quantity as will do the required work for each stroke. The expanded gases of combustion are forced out of the cylinder during the third stroke, while the fourth stroke draws fresh air into the cylinder. This is the sequence of events in a four-cycle engine.

By expelling the burned gases with fresh air the necessary functions can be performed in two strokes of the piston, producing the so-called two-cycle engine.

The above-mentioned engine should not, however, be confused with the two-cycle oil engine as used in railway and other pumping stations and termed the Semi-Diesel engine. In order to avoid the high compression pressure and the resulting complication of design necessary in the Diesel engine this so-called Semi-Diesel engine has been devised, which does not compress the air sufficiently to raise the temperature to such a point that it will spontaneously ignite the injected fuel. It is this type of engine which we have to deal with, particularly with the two-cycle valveless injection engine, in which the compression has been reduced, adding the required temperature in a heated combustion chamber. This engine is governed by throttling the oil supply and ignition is accomplished by means of a hollow ball. This ball is heated by a blow torch before starting, but after the engine is running the heat is maintained by the successive explosions. The fuel is introduced through fuel valves similar to the Diesel engine, but much less compression of air is required, the compression of the Semi-

TABLE III.

Reference number of oils	1	2	3	4	5	6	7
Gallons of oil used per hour	1.51	2.29	2.04	1.88	2.19	2.00	2.10
Pounds of oil used per hour	11.30	17.33	14.07	12.20	16.38	14.40	15.07
Pounds of oil used per W. H. P.	1.02	1.12	.98	.80	1.01	.96	.85
Engine R. P. M.	346	337	345	345	342	338	328
Pump R. P. M.	40	39	40	40	40	39	38
Gallons pumped per minute	144	603	583	592	586	580	577
Cost of oil, per gal.	.029	.029	.031	.03	.029	.025	.016
Cost of oil per hour	.044	.066	.063	.056	.063	.05	.035
Cost per 1,000 gal.	.0016	.0019	.0022	.0016	.0018	.0015	.0009

---

*Paper before joint annual convention of the Illinois Section of the American Water Works Association and the Illinois Society of Engineers and Surveyors.

Diesel engines being from 80 to 30 lb. Crank case compression is $1\frac{3}{4}$ to $3\frac{1}{2}$ lb.

Although these engines have a theoretically less efficient heat cycle than the Diesel they gain in simplicity of construction.

Intelligent lubrication is essential to the proper operation of the oil engine. Improper lubrication contributes largely to oil engine trouble. The high speeds and temperature at which these engines work necessitates a continuous and skillful use of good oil. A great deal depends upon the proper lubrication of an engine of this type and the prevention of the carbon forming in the cylinder. The destruction of the lubricating oil by combustion cannot be prevented. Just what occurs to the oil in an internal combustion engine cannot be entirely explained, but there is no doubt that a great deal of it is burned along with the fuel oil and as long as this is true it is necessary that complete combustion take place, in order that a residue of unburnt oil is not left in the cylinder in the form of carbon.

The lubrication of the steam engine or pump is comparatively simple. In steam engines there is a certain amount of moisture to assist lubrication, but the flames of an oil engine dry the internal surfaces and unless the proper amount of oil is applied the cylinder, piston and rings soon begin to suffer. In a steam engine or pump the temperature will at the most reach about 500°, while in an oil engine it rises to as high as 2,500°. Added to this is the fact that the piston speed of an internal combustion engine is from three to four times that of a steam engine or pump. Consequently the oil engine requires a different method of lubrication and a great deal more of it.

Engines of this type are liable to suffer from carbon trouble and resultant deterioration due to the fact that an excess of oil injected into the cylinder breaks up into volatile compounds, such as the naphthas, heavy tar-like oils and free carbon.

Overloading the engine also will cause carbon trouble. When the engine is working up to its maximum power a momentary overload will cause an excess of oil and the resultant accumulation of carbon due to the fact that the oil engine is not flexible enough to adjust itself instantly to the varying loads as does a steam engine or pump.

The carbon troubles may be reduced to the minimum by the use of the proper oil. Fuel oils vary in quality, as do hard and soft coal, and even to a greater extent. As a result some oils are better suited for use in oil engines than others. While it is possible to burn almost any oil that will flow freely, the best results are to be obtained from oils of a parafine base from 30 to 36° Baume.

Test No. 3.—A number of tests were conducted on a 25-HP. oil engine with a 10x14-in. cylinder belted to a 10x12-in. Duplex power pump, using seven different kinds of oil, ranging from a heavy fuel oil of an asphalt base to a light distillate of a parafine base. A brief description of the oils used follows:

No. 1.—Diesel fuel oil, 26° Baume, made from asphaltum base crudes from Texas and Louisiana fields. No. 2—Gulf fuel oil, 24° Baume, made from asphaltum base crudes from Oklahoma fields. No. 3—Narico distillate, 39° Baume, made from semi-parafine base mid-continent crudes. No. 4—Motor oil, 42° Baume, made from parafine base crudes from Cushing Oklahoma fields. No. 5—Navy fuel oil, 26° Baume, made from asphaltum base crudes from Texas and Oklahoma fields. No. 6—No. 1 fuel oil, 32° Baume, a non-sulphur oil parafine base from Illinois crudes. No. 7—Kentucky crude oil, 32.5° Baume, parafine base.

Table III gives the results obtained from the use of the above oils. The costs given cover the fuel only:

While these tests are not conclusive, they indicate the wide range of fuels it is possible to burn in these engines.

Tables IV and V give the result of tests conducted in pumping with 4-in. centrifugal pumps using two-cycle Semi-Diesel oil engines for power, one pump being driven by a 25-HP. horizontal engine and the other by a 25-HP. vertical engine, both pumps being belt-driven. Table IV gives the result of one hour's run, while Table V gives the hour run and cost for a period of four months for each engine.

TABLE IV.—TEST ONE HOUR'S RUN.

	Horizontal engine.	Vertical engine.
R. P. M. engine	315	380
R. P. M. pump	1587	1320
Gallons pumped per minute	571	571
Total head in feet	77.38	79.69
Fuel oil consumed in gallons	2.25	2.65
Water horsepower	11.15	11.5
Brake horsepower	21.4	22.1
Cost fuel oil per million gallons	$1.67	$1.97
Cost of fuel oil per gallon	.0253	.0253
Cost per HP. hr	.0026	.0030

TABLE V.—COST OF FUEL AND LUBRICANTS FOUR MONTHS' RUN EACH ENGINE.

	Horizontal engine.	Vertical engine.
Total number of hours run	331	316
Gallons water pumped	9,930,000	9,480,000
Cost of kerosene	$3.78	$1.50
Cost of fuel oil	18.01	18.47
Cost of lubricants	9.20	10.20
	$30.99	$30.17
Cost per 1,000,000 gal	3.12	3.18

Tables VI and VII show the results obtained in pumping with a 25-HP. horizontal two-cycle heavy oil engine belted to a 10x12-in. double acting duplex power pump and a 30-HP. vertical two-cycle heavy oil engine belted to a 11x12-in. single acting triplex power pump. Table VI gives the results for one hour's run and Table VII cost for a period of four months, each engine.

TABLE VI.—TEST ONE HOUR'S RUN.

	Duplex pump. horizontal engine.	Triplex pump, vertical engine.
R. P. M. engine	342	396
R. P. M. pump	40	44
Gallons pumped per minute	586	640
Total head in feet	104	106
Fuel oil consumed in gallons	2.19	2.70
Water horsepower	15.33	17.5
Brake horsepower	20.44	23.33
Cost fuel oil per million gallons pumped	$1.80	$2.00
Cost fuel oil per gallon	.029	.029
Cost per HP.-Hr	.0031	.003

TABLE VII.—COST OF FUEL AND LUBRICANTS FOUR MONTHS' RUN EACH ENGINE.

	Duplex pump hor. engine.	Triplex pump vert. engine.
Total number of hours run	687	677
Gallons water pumped	24,732,000	24,372,000
Cost of kerosone	$8.52	$9.78
Cost of fuel oil	26.26	31.37
Cost of lubricants	17.10	22.04
Total cost	$51.88	$63.19
Cost per million gallons	2.09	2.54

Although the oil engine cannot yet be considered as fully developed, it has passed the experimental stage, and while they are, perhaps, not as reliable under all conditions as a steam engine or pump, much of the prejudice against the oil engine is undoubtedly due to lack of experience in handling. With the present imperfect knowledge of what the engine is capable of doing and of what particular oils may be burned in it, one cannot speak conclusively, but there is no doubt that the future of the engine is assured.

Important Drainage Conference.—An important conference on drainage and related subjects will be held at the University of Illinois under the auspices of the Department of Civil Engineering, March 8-11, 1916. Land reclamation, flood protection, levee construction, and the importance of such work to the agricultural interests of the State are subjects which will be discussed by engineers and contractors who have specialized in such work. The program includes the names of such men of prominence as: George Parsons, President of the National Drainage Congress; Edmund T. Perkins, and Isham Randolph, Consulting Engineers; S. H. McCrory, Chief of Drainage Investigations, U. S. Department of Agriculture, and W. L. Park, Illinois Central Railroad. The practicability will be considered of having an annual short course in Drainage Engineering under the direction of Professor F. H. Newell, head of the Department of Civil Engineering and formerly director of the United States Reclamation Service. All who are interested in the subjects mentioned are cordially invited to attend. The Department of Civil Engineering, Urbana, will send full information on request.

PRICES OF STEEL PRODUCTS COVERING PERIOD 1898-1915.

The curves of Fig. 1 show the Pittsburgh prices for steel billets and finished steel products, per gross ton (2,240 lb.), covering the period 1898-1915, as compiled by The Iron Age. These curves very clearly indicate comparative and actual monthly prices during the period covered. In explanation of the high and low values the following discussion is given by the authority quoted:

The chart starts with 1898, as that was the year in which the depression following the panic of 1893 showed its most disastrous effects upon iron and steel prices. The low points of 1898 make the peaks of 1899 the very striking feature of the chart. After the starved consumption of the panic period demand developed in 1899 that found capacity entirely inadequate. Almost as striking in the other way are the declines of 1900. In 1901, prices were fairly steady, with advances in the latter part of the year bringing another series of high points in 1902, though these are moderate in comparison with 1899. The sharp decline of 1903 is distinctly shown; the slight further decline extending over nine months of 1904, with advances in the latter part of the year; some reaction in 1905, followed by advances in the latter part of the year; some reaction in 1905, followed by advances in the latter part of the year and a comparatively stable level for the first half of 1906. Then came a strong movement upward, until substantially the levels of 1902 were reached, followed by recessions after the middle of 1907 in billets, but finished material prices were held in the weeks following the October panic. The co-operative movement among steel manufacturers modified the decline in the depression of 1908, and in the spring of 1909 came abrupt declines in response to the insistence of some steel manufacturers, particularly of bars, that prices had been kept too high. These cuts stimulated buying which gave the strong upward trend of the second half of 1909. In general, 1910 was a year in which the price movement reversed that of 1909, but finished materials only retraced part of the distance to the bottom touched after the open market declaration of February, 1909. Steadily declining prices marked 1911. The break in finished material in May, following notice by the Republic Iron & Steel Co. that it proposed to reduce its prices, is plainly indicated in the pitch of the curves. There was a slight recovery in December. Early in 1912, however, active competition developed a further decline, and the low point for the year was touched in February in some products and in March in others. Gradually rising prices marked the late spring and summer and fall months. The high prices paid for early deliveries were a prime feature of the first four months of 1913. In May, prices for early and for future delivery came closer together, and by June premiums on prompt steel had practically disappeared. Business fell off as the summer advanced. This became more pronounced later, and in the last four months of the year price declines became marked. In 1914, finished materials gradually drooped as consumption fell off. There was an effort to advance prices in August, under the belief that the war would cause an increased call for American steel. This demand was not large, however, and business at home continued to fall off, the lowest prices of the year being reached in December, when many plants operated at only about one-third capacity. January, 1915, brought some activity to make up for the extreme depression just preceding. As spring came on war demand for steel increased, and export prices advanced. An unparalleled scarcity of steel developed in the late summer and billets advanced rapidly. Plates late in the year went soaring and wire products reached the highest point for 15 years in December.

Prices used in plotting the charts are those asked by producers for delivery in from one to three months, and thus do not represent the extreme prices paid at times for prompt delivery.

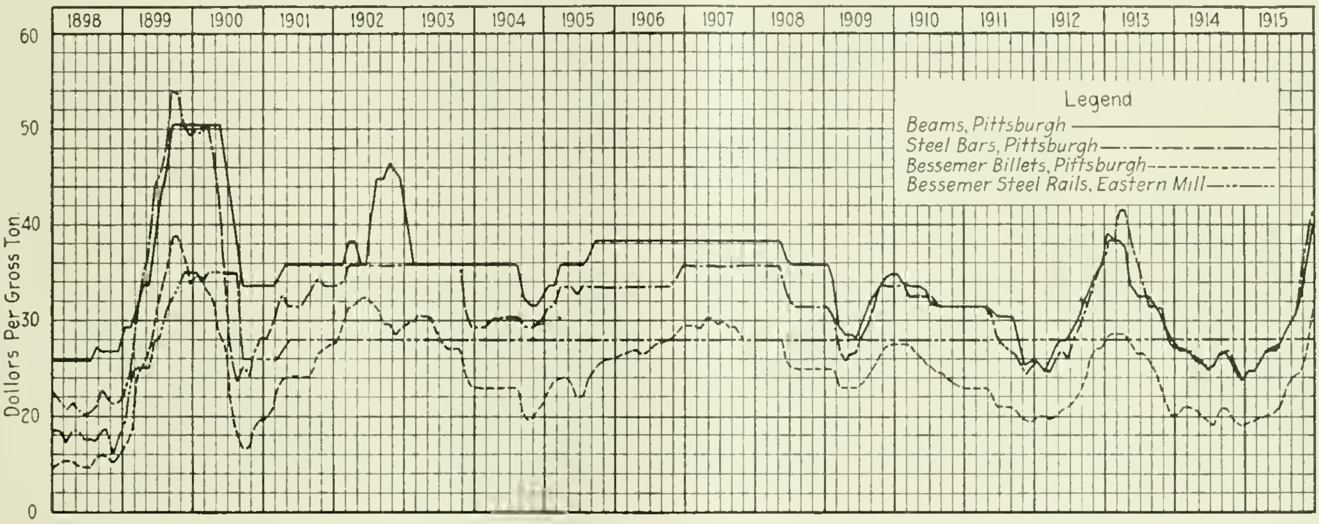


Fig. 1—Curves Showing Pittsburgh Prices Per Gross Ton of Steel Billets and Finished Steel Products Covering Period 1898-1915.

Unwise Water Rate Lowering at Columbus, O.—A Columbus, Ohio, newspaper comments as follows on the results of a downward revision of water rates in that city several years ago: "A few years ago the water rental charged consumers by the city was decreased to redeem a campaign pledge. With the revenue thus reduced it has since been necessary to issue bonds to make water works extensions. These bonds help increase the interest and sinking fund charges which annually must be deducted from the city's income for running expenses. This is one of several reasons that the city now faces a deficit of $700,000 in its estimated running expenses for 1916. The situation now seems to be that the city must drop some of its work or the people must vote more taxes on themselves. And the question naturally arises—wherein did the taxpayers profit by the reduction of the water rate?"

North Carolina Road Institute.—The third annual Road Institute, held at the University of North Carolina February 7-12 under the auspices of the State University, State Highway Commission and North Carolina Geological Survey, was highly successful and stimulating to the cause of better roads in North Carolina. The features of the Institute were lectures and discussions of problems relating to the location, construction and maintenance of roads; and exhibits and demonstrations of road building machinery. A large room adjacent to the auditorium of one of the University buildings was used for the exhibit of pictures of various types of roads and bridges built in different parts of the state, maps, literature on the science of road building, models, and samples of road surfacing materials. Road drags, wheel scrapers and road machines, supplied by the manufacturers, were actually demonstrated on the streets of the town by experts. A large 48-in. semi-circular culvert was constructed on the campus.

UNIT COSTS IN CONSTRUCTION.*

By Sanford E. Thompson, Consulting Engineer, Boston, Mass.

The aim of this paper is to call attention to the necessity for more accurate estimates by architects, engineers, and contractors, and to the possibility of reducing construction costs by a more thorough analysis and systematizing of the labor operations.

Open any technical paper giving construction items and we notice the enormous variation in bids received from contractors for the same job. At random I open a current engineering periodical and find the four bids on a certain job: $117,000, $126,000, $143,000, and $171,000. This does not represent an exceptional case, but is the general rule on work in which the cost of labor is relatively large.

Unquestionably the methods of management, especially on construction jobs, affect the cost to a very large extent, but it is hardly conceivable that differences of, say, 50 per cent in cost can be accounted for in this way. Assuming, as is generally the case, that the bidders really try for the job, there is evidently gross error in many cases in the estimating. The variations must be due to one of three causes: (1) inaccurate estimate of volumes or costs of materials; (2) inaccurate estimates of labor costs; or (3) inaccurate estimates of overhead costs and profits. Note that I have combined the items of overhead and profit because they are practically interdependent. The contractor, for example, who handles a job personally has small overhead expenses but requires larger profits to make up for the value of his own time than does a large contractor whose overhead in salaries and plant are large but whose percentage of profit may be small and yet yield a large total income.

Material costs usually are figured without trouble. The variation in overhead by two different estimators may be large because many contractors do not properly charge or divide their overhead items, but this difference on any one job can hardly account for more than 10 per cent. The big variation, then, must be in the estimated labor cost. As a matter of fact, this is the item on which money is made or lost in contracting.

A contractor was asked recently why he did not bid on a certain reinforced concrete bridge. The reply was: "I have built mine." Construction companies handling reinforced concrete will tell you that a contractor does not begin to make money till he gets his third job, provided he stays in the game as long as this. The first job costs him more than his estimate; he bids low on the second job because he thinks he sees where he lost money on the first; on the third job he knows he has been a fool and adjusts his bid accordingly.

It must be the aim not simply to know how to do the work cheaply but to figure estimates more accurately, at the same time taking care to keep the cost of the figuring as low as possible. It is useless to get a job at a low figure and lose money on it. It is evident, further, that having made the bid with care, the construction must be handled in such a way as to come within the limit set. This requires not simply a fair comparison with the monthly estimates, but the follow-up from day to day of quantities and wages so as to have a running check on the work. It takes but little more time in figuring an estimate where material costs are estimated in detail to go also into unit costs of labor. This of course is not simply a mathematical proposition but requires a knowledge, based on first-hand experience, of actual costs, or else on records where conditions are stated in full.

In reinforced concrete construction, the greatest discrepancy lies in the cost of forms. It is here that the contractor and also the engineer are apt to be fooled, unless either they are well provided with unit costs or else have handled work previously of an identical nature. Suppose, for example, a builder has been accustomed to building forms for heavy concrete, such as core walls for dams, heavy foundation work, and mass construction. He finds from his records that the cost of labor for such forms, not including overhead and profit, is $0.50 per cubic yard. He bids on a reinforced concrete building, and adds, say, 50 per cent, or say, 100 per cent to be on the safe side, and such a percentage guess as this is by no means uncommon in estimating, and figures $1.00 per cubic yard for labor on forms. Instead of the $1, he may find the cost to be about $4 per cubic yard, and discovers further that the cubic yard basis is absolutely incorrect. He then adopts the square foot as the unit. This is better, but let us see how this may work out.

Suppose that his first job in building construction is a design calling for 250 pounds per square foot of working load, with long spans, columns averaging 24 in. square, and beams and girders of similarly large size. The new job, we will say, has a load of 125 lb. per square foot with columns averaging 15 in. and correspondingly smaller beams and girders. He realizes that he must not use the cubic yard unit for figuring his forms. If he did use this, he would find when he got through that the cost per cubic yard of his labor on the smaller size members was nearly double that on the other job. He uses then the square foot basis. On the building with heavy load, the labor cost of the column forms, using columns only, to be specific, was, we will say, 8.3 ct. per square foot. We will suppose he uses this on the building with light loads. The estimate will be absolutely incorrect. It costs only a little less to make and to erect the smaller forms than the larger, although, on the other hand, enough less to throw the scale in the other direction if the cost is assumed equal, member for member. On the light load building, as a matter of fact, the labor cost on the 15 in. columns is about one-quarter greater per square foot than the cost on the building with columns averaging 24-in. square, while the cost per member is 16 per cent less. Costs, based on accurate unit averages, checked by work on various jobs, show the following comparison of 15 in. and 24 in. column costs, each in a building of 12 ft. total story height, and all other conditions the same.[1]

Size of column.	Cost per cu. yd.	Cost per sq. ft.	Cost per member.
24-in.	$4.50	$0.083	$8.00
15-in.	9.68	0.105	6.74
Per cent increase	115	27	16*

*Decrease.

You may say that this is an extreme case, but I am quoting almost exactly from an actual case of a contractor of large experience in building construction but with limited experience in reinforced concrete construction, who used, not the square-foot method, but the cubic-yard method of estimating in two buildings with heavy and light load. Fortunately for him, he built the heavy building first, and so simply lost the job on the second building by figuring way up in the air.

Much has been written of the inaccuracy of "cost data" and with perfect truth. On the other hand, if the unit costs are taken from personal experience or from records in which all the local conditions are fully stated and average values compiled, they are of immense value in estimating and in following up the work. Care must be taken of course to provide for indirect charges, such as foreman, sharpening tools, time on miscellaneous work, plant erection, and contingencies. In addition to these are the charges for superintendence, contingencies chargeable to labor but not estimated as part of pay roll, odd tools and appliances not carried to next job, liability insurance, etc.

To illustrate the variations in labor costs of different members in form construction, Table I presents a few values selected from "Concrete Costs."[2]

Costs of this kind are useful not merely for contractor's estimate, but perhaps even more for comparing different designs by engineers and architects. Reference might be made, for example, to studies for the new Technology buildings, given in the paper presented by the author last year, in which it was found that for three different types of floor design a long span slab was the

---

*Paper read before the American Concrete Institute, Feb. 14, 1916.

[1] From "Concrete Costs," by Taylor and Thompson, 1st Edition, p. 631.

[2] For complete tables, see "Concrete Costs," by Taylor and Thompson, 1st Ed., pp. 630 to 654.

TABLE I.—LABOR COSTS OF FORMS FOR COLUMNS, BEAMS, GIRDERS, AND SLABS.

Costs include 10% for foreman and 15% for superintendence, contingencies, etc., but do not include profit or home office expense. Carpenter labor, 50c per hour; ordinary labor, 25c per hour. Material, 1-in. lumber.

Size.	Make form.	Place and and remove form, first time.	Place and remove form after first time.	Remake, place and remove form.
12-Foot Columns—Labor Cost per Member, Iron Clamps.				
8-in. by 8-in.	$1.16	$4.68	$3.77	$5.53
16-in. by 16-in.	1.46	5.45	4.40	6.16
24-in. by 24-in.	1.80	6.20	5.14	6.86
36-in. by 36-in.	2.61	7.64	6.33	8.14
20-Foot Beams—Labor Cost per Member, Size Measured Below Slab.				
4-in. by 8-in.	$0.92	$2.42	$1.97	$2.79
6-in. by 12-in.	1.09	2.75	2.31	3.23
8-in. by 16-in.	1.26	2.99	2.59	3.64
12-in. by 24-in.	1.75	3.41	3.09	4.29
20-Foot Girders—Labor Cost per Member, One Intersecting Beam.				
8-in. by 16-in.	$1.38	$3.27	$2.75	$4.31
12-in. by 24-in.	1.82	3.86	3.20	5.02
Labor Cost of Slab Forms.*				
Per 100 square feet of slab surface	$.81	$2.53	$1.90	$2.06

*Based on slab built two panels per bay.

For inexperienced builders, increase costs 33⅓%.

For special design, add 10% to 50% to "Make Forms."

If no mill saw on job, add 50% to "Make Forms."

If old lumber is used, add 75% to 100% to "Make Forms."

For rectangular columns, select values for square columns having the larger dimension of the rectangle.

For wall columns, add 50 % to all except "Make Forms."

cheapest on account of the difference in the cost of form construction.

Reductions in Construction Costs.

Up to this point has been considered the substitution of accurate methods for guess work in estimating. The more important question is how far the knowledge, such as has been referred to, can be utilized in reducing costs. Accurate cost keeping is of value in following up construction costs from day to day in showing up waste labor and in providing a mark for the attainment of superintendents and foremen. Unless cost knowledge is in the form of small units, such comparisons cannot be made satisfactorily.

To get the full benefit of a knowledge of unit costs, and in fact for this the knowledge must be even more thorough and include the unit times of performing the various operations, it must be utilized in the planning of the work in advance and in distributing materials and jobs; in selecting materials and methods which will result in lowest labor costs; in adapting the construction plant to the special conditions; and, carried to its ultimate end, in laying out jobs for the workmen and giving them a reward for accomplishment.

Such management as this involves the adoption of factory methods in construction. Already the need of this is being recognized, but only to a limited degree. The president of one of our large and most up-to-date construction companies advised me recently that on one job he made a saving of $10,000 by the adoption of methods involving systematic planning and routing.

Limitation of time forbids a more complete discussion of this most important problem. Full economy in construction, however, will only be attained as the builder discards the haphazard rule-of-thumb method and considers his job with a view to thorough analysis, planning functional methods, and a complete study of details. By such methods as these will the labor of construction be brought to a more scientific basis and more nearly on a par with the material end of the work.

SOME ECONOMIES EFFECTED IN WATER WORKS MAINTENANCE AND EXTENSION AT BALTIMORE.

The water department of Baltimore, at the close of its period of heavy construction, has been undergoing a reorganization. In introducing the new scheme of organization Mr. Calvin W. Hendrick, the Chief Engineer of the city, and Mr. Walter E. Lee, Water Engineer, have issued the following order:

Watchmen with mains foremen will not be employed on the day shift, one watchman being allowed from 4 p. m. to 11 p. m., and another from 11 p. m. to 7 a. m.

Clay roll runners are discontinued and asbestos pipe runners are to be purchased, which will dispense with the services of the man who made up the clay rolls.

Melting lead in open ladles with expensive wood fires is discontinued, and gasoline melting pots of various and portable sizes are to be employed instead.

The mains foreman, being visited in the field every day by the assistant engineer in charge of construction, will, therefore, remain on their respective jobs a full eight hours every day, receiving their instructions on new jobs from the assistant engineer in person. There will be no car fare expense allowed or approved by this office, as there is no apparent necessity for their reporting in, as has been their custom in the past.

All foremen, whether mains, meter or repair, will not be employed when rainy days do not permit of their work going ahead, but foremen, on the same basis as the other class of per diem labor, will be paid for the actual time which they make in productive work.

The assistant foremen are abolished, because with the foremen themselves in direct charge of their working forces the entire eight hours of the day there is no necessity for assistant foremen. The foremen, even where the work is scattered, with large gangs, can range back and forth from point to point, as it is not necessary that they be continually at a point while the job is going on.

A timekeeper with engineering training takes the time of all men employed with mains foremen, independently of the daily time sheets, which will continue to be turned in by the foremen. This timekeeper will also assist the engineer of line and grade whenever necessary in construction work.

All teams, except the 10 employed on service, meter and fire service installations, are abolished. Additional motor trucks will be purchased if it is deemed necessary, in the opinion of the Water Engineer.

For the turn-off and turn-on of house services the city will be divided into six districts, in charge of the pitometer engineer, the men assigned to the outlying districts being equipped with motorcycles, and carrying with them a folding key.

The paving inspectors are abolished, as the Water Engineer will install roadway boxes of an adjustable type, and the Paving Commission, Highways Engineer and the Commissioners for Opening Streets will assume the direct responsibility of bringing valve boxes to correct grade.

Emergency complaints that come in to the construction and maintenance division should be first investigated rapidly and quickly by a man on a motorcycle, who will size up the situation and telephone to headquarters the size of gang and amount of material which he estimates necessary for the proper making of repairs. This will eliminate gangs of six or seven men that now go to one location for the purpose of turning off a single broken house supply.

ACCURATE DETAILED COST DATA ON USE OF AUTOMOBILES IN ROAD SUPERVISION.

Contributed by E. W. James, Chief of Road Maintenance, Office of Public Roads and Rural Engineering, Washington, D. C.

The use of three low-priced cars on the Washington-Atlanta Highway, over which the Office of Public Roads and Rural Engineering is supervising maintenance, has furnished an opportunity to secure accurate cost data relative to any desired details of operation. The cars

TABLE I.—SUMMARY OF AUTO RECORDS FOR 1915.

Month.	Car No. 1			Car No. 2			Car No. 3		
	Miles run.	Total cost.	Cost per mile.	Miles run.	Total cost.	Cost per mile.	Miles run.	Total cost.	Cost per mile.
January	563	$ 43.19	$0.0767	807	$ 39.75	$0.0493	203	$ 31.35	$0.1546
February	.....	9.60	......	780	45.85	0.0587	583	13.61	0.0234
March	635	62.25	0.0979	1,557	64.42	0.0413	1,169	32.63	0.0278
April	848	20.49	0.0241	1,404	64.37	0.0457	1,391	37.01	0.0265
May	1,023	51.50	0.0504	1,947	64.81	0.0333	1,322	59.33	0.0448
June	865	32.78	0.0376	1,198	61.10	0.0508	1,456	74.99	0.0514
July	838	47.89	0.0570	1,461	37.24	0.0255	1,412	50.89	0.0360
August	1,031	48.19	0.0468	690	15.19	0.0220	1,495	61.75	0.0414
September	1,018	28.02	0.0275	1,249	53.20	0.0426	965	42.65	0.0442
October	1,070	46.78	0.0436	1,366	65.28	0.0478	1,195	34.96	0.0292
November	978	31.40	0.0321	1,485	47.49	0.0319	1,172	46.99	0.0401
December	1,149	53.39	0.0465	1,240	43.49	0.0350	1,156	63.68	0.0550
1915—Totals	10,018	$475.48	$0.0475	15,184	$602.19	$0.0397	13,519	$549.84	$0.0407
1914—Totals	6,210	....	....	9,308	....	....	8,712	....	....
Grand totals	16,228	....	....	24,492	....	....	22,231	....	....

TABLE II.—WEIGHTED AVERAGES OF TOTAL OPERATION COSTS AND COMMON AVERAGE FOR ALL CARS.

Item.	Car No. 1			Car No. 2			Car No. 3			
	1914.	1915.	Weighted averages.	1914.	1915.	Weighted averages.	1914.	1915.	Weighted averages.	Common average.
Average cost of gas per gallon (cents)	20.01	18.96	19.35	18.96	18.32	18.56	16.77	16.18	16.41	18.10
Miles run per gallon of gas	17.52	16.29	16.74	17.45	15.66	16.29	19.73	19.76	19.75	17.59
Miles run per pound of grease	282.27	500.90	386.38	340.58	446.59	399.35	458.53	500.70	483.28	423.00
Miles run per quart of oil	62.73	47.03	52.01	81.65	45.06	54.31	86.26	97.87	92.97	66.43
Cost per mile of—	Cents.	Cents.	Cents.	Cents.	Cents.	Cents.	Cents.	Cents.	Cents.	Cents.
Gasoline	1.14	1.16	1.16	1.09	1.17	1.14	0.85	0.82	0.83	1.04
Grease	0.05	0.04	0.04	0.05	0.04	0.04	0.03	0.03	0.03	0.04
Oil	0.24	0.33	0.30	0.17	0.30	0.25	0.17	0.14	0.15	0.23
Tire casings	1.15	0.55	0.79	0.90	0.49	0.65	0.48	0.55	0.52	0.65
Other tire cost	0.17	0.26	0.22	0.07	0.22	0.16	0.20	0.15	0.17	0.18
Storage charges	0.89	0.60	0.71	0.28	0.22	0.25	0.64	0.59	0.61	0.52
Miscellaneous	0.76	*1.81	1.41	†1.23	1.53	1.42	†1.28	1.79	1.59	1.47
Total	4.49	4.75	4.63	3.79	3.97	3.91	3.65	4.07	3.90	4.13

*Includes general overhauling in March. †Inculdes general overhauling at end of November.

TABLE III.—DETAILED OPERATION COST DATA FOR CAR NO. 1.

Month.	Gal. of gas.	Cost of gas.	Qt. of oil.	Cost of oil.	Pounds of grease.	Cost of grease.	Storage charges.	Tire casing charges.	All other tire charges.	Miscel-laneous.	Total.
January	59	$ 11.84	18	$ 3.00	..	.....	$ 7.50	.....	.....	$ 20.85	$ 43.19
February	...	.....	...	.....	..	.....	7.00	.....	.....	2.60	9.60
March	53	10.40	16	2.40	1	$0.15	1.50	.....	$ 2.50	45.30	62.25
April	50	9.04	15	2.15	2	0.30	5.75	.....	.....	3.25	20.49
May	63	10.95	19	3.05	4	0.60	8.75	$12.35	4.25	11.55	51.50
June	53	8.78	14	2.10	1	0.15	3.00	.....	1.00	17.75	32.78
July	43	7.24	22	3.40	3	0.45	5.50	18.70	6.15	6.45	47.89
August	49½	8.59	22	3.55	3	0.30	5.75	12.15	7.45	10.40	48.19
September	46½	8.17	24	3.85	1	0.15	5.75	2.70	.25	7.15	28.02
October	60	11.88	20	3.05	2	0.20	4.00	.....	2.30	25.35	46.78
November	61	12.80	18	2.75	..	.....	3.00	.....	.25	12.60	31.40
December	77	16.94	25	3.75	3	0.45	3.00	9.60	1.25	18.40	53.39
Totals	615	$116.63	213	$33.05	20	$2.75	$60.50	$55.50	$25.40	$181.65	$475.48

Average cost of gasoline per gallon	$0.1896	
Miles per gallon of gasoline	16.29	
Miles per pound of grease	500.90	
Miles per quart of oil	47.03	
Cost per mile or gasoline	$0.0116	24.4%
Cost per mile of grease	0.0004	0.8%
Cost per mile of oil	0.0033	7.0%
Cost per mile of tire casings	0.0055	11.6%
Other tire costs per mile	0.0026	5.5%
Cost per mile of storage charges	0.0060	12.6%
Miscellaneous charges per mile	0.0181	38.1%
	$0.0475	100.0%

have now been in use since May 24, 1914, and records are complete through December, 1915.

The data here presented are principally for the calendar year 1915, but in Table II, weighted averages are shown for total operation costs since cars were put into service, and in the last column is the common average for all cars for the whole period.

TABLE IV.—DETAILED COST DATA FOR CAR NO. 2.

Month.	Gal. of gas.	Cost of gas.	Qt. of oil.	Cost of oil.	Pounds of grease.	Cost of grease.	Storage charges.	Tire casing charges.	All other tire charges.	Miscel-laneous.	Total.
January	61	$ 10.89	11	$ 1.65	5	$1.25	$ 3.75	.....	.....	$ 22.21	$ 39.75
February	58	10.83	9	1.35	4	0.60	0.75	.....	.....	32.32	45.85
March	95	17.32	26	3.85	2	0.25	4.75	.....	$24.80	13.45	64.42
April	81	14.43	37	4.91	7	0.80	3.50	.....	.....	40.73	64.37
May	117½	17.96	76	10.70	9	1.15	6.20	.....	.....	28.80	64.81
June	74	13.15	28	3.90	5	0.75	4.75	$11.35	.....	27.20	61.10
July	95½	15.69	24	3.45	..	.....	2.25	8.00	3.20	4.65	37.24
August	54	9.39	21	2.65	..	.....	0.25	.....	0.40	2.50	15.19
September	75¼	14.61	21	2.65	1	0.10	0.75	13.39	1.55	20.15	53.20
October	78½	15.94	25	3.20	..	.....	1.50	19.82	3.87	20.95	65.28
November	97½	19.46	37	4.30	1	0.15	1.75	8.90	.....	12.05	47.49
December	82½	18.02	22	2.85	..	.....	3.75	12.90	.....	5.97	43.49
Totals	969¾	$177.69	337	$45.46	34	$5.05	$33.95	$74.36	$33.82	$231.86	$602.19

Average cost of gasoline per gallon	$0.1832	
Miles per gallon of gasoline	15.66	
Miles per pound of grease	446.59	
Miles per quart of oil	45.05	
Cost per mile of gasoline	$0.0117	29.8%
Cost per mile of grease	0.0004	0.1%
Cost per mile of oil	0.0030	7.6%
Cost per mile of tire casings	0.0049	12.4%
Other tire costs per mile	0.0022	5.6%
Cost per mile of storage charges	0.0022	5.6%
Miscellaneous charges per mile	0.0153	38.9%
	$0.0397	100.0%

The car having the lowest mileage to date has run an average of 28.4 miles a day, 30 days a month since going into service. The highest mileage shows 42.9 miles per day for the same period. The cost of transportation per mile of road under supervision averages 20 ct. per month. The only comparable figures for use of livery for similar work show a cost of approximately 52 ct. per mile per month for transportation. These figures, taken in connection with the large possible saving of time which has been actually developed by the field men of the Office of Public Roads and Rural Engineering, indicate that for such work the automobile in comparison with livery is both economical of time and money.

TABLE V.—DETAILED COST DATA FOR CAR NO. 3.

Month.	Gal. of gas.	Cost of gas.	Qt. of oil.	Cost of oil.	Pounds of grease.	Cost of grease.	Storage charges.	Tire casing charges.	All other tire charges.	Miscel-laneous.	Total.
January	10	$ 1.30	...	...	..	.....	$ 7.50	.....	.....	$ 22.55	$ 31.35
February	35	4.76	8	$ 1.00	..	.....	7.00	.....	.....	0.85	13.61
March	50½	7.73	12	1.50	1	$0.10	7.00	$ 9.40	$ 2.50	4.40	32.63
April	67½	9.41	5	0.65	4	0.40	6.75	10.60	.....	9.20	37.01
May	66	9.28	12	1.70	3	0.30	6.75	13.10	4.25	23.95	59.33
June	80¾	11.47	23	3.00	6	0.85	5.75	.....	0.40	53.52	74.99
July	69	9.44	11	1.65	3½	0.70	6.75	24.00	0.50	7.85	50.89
August	72	11.28	15	2.25	2½	0.50	6.50	.....	.....	41.22	61.75
September	54	9.20	16	1.80	2	0.20	6.50	5.25	7.65	12.05	42.65
October	62	11.71	12	1.80	2	0.50	6.25	.....	2.65	12.05	34.96
November	55	10.62	12	1.80	2	0.30	6.00	12.10	2.00	14.17	46.99
December	62½	14.53	12⅛	1.95	1	0.10	6.75	.....	0.60	39.75	63.68
Totals	684¼	$110.73	138⅛	$19.10	27	$3.95	$79.50	$74.45	$20.55	$241.56	$549.47

Average cost of gasoline per gallon	$0.1618	
Miles per gallon of gasoline	19.76	
Miles per pound of grease	500.70	
Miles per quart of oil	97.87	
Cost per mile of gasoline	$0.0082	20.1%
Cost per mile of grease	0.0003	0.8%
Cost per mile of oil	0.0014	3.4%
Cost per mile of tire casings	0.0055	13.5%
Other tire costs per mile	0.0015	3.7%
Cost per mile of storage charges	0.0059	14.5%
Miscellaneous charges per mile	0.0179	44.0%
	$0.0407	100.0%

Engineering and Contracting

Devoted to the Economics of Civil Engineering Design
and to Methods and Cost of Construction

EDITORS

H. P. Gillette C. S. Hill C. T. Murray S. C. Hadden C. W. Malcolm

Volume XLV. CHICAGO, ILL., MARCH 8, 1916. Number 10.

A RATIONAL SPECIFICATION FOR GRAVEL AGGREGATE FOR CONCRETE.

No group of engineering materials, perhaps, is the subject at the present time of so many independent experimental studies as are aggregates for concrete. It is high time that these studies should be undertaken. To review all this research now in progress is not our purpose. The time for such a review has not yet arrived. Few of the studies being made have been carried sufficiently toward completion to make review and summary useful. There is one phase of the investigation, however, to which attention is attracted particularly and which, therefore, may be properly noted at this time. This is the growing appreciation of the value of gravel as a concrete aggregate and an equivalent growing discontent with our knowledge of the material in its more intricate characteristics.

Specification writers have been very much in the habit of including broken stone and gravel in one class as coarse aggregate. It is coming to be seen that a radical difference exists between the two. Consider alone the difference in shapes of the particles of broken stone and of gravel. In stone they are vertical and angular, in gravel they are spherical and smooth. Can it be doubted that the voids existing in masses of the two kinds of particles are different in size and shape and require different proportioning and grading of the fine aggregates? This at least is the position assumed by Prof. H. H. Schofield and Mr. Charles Carrol Brown in a suggestive paper before the American Concrete Institute and in which they announce a plan of tests for and voice an urgent plea for a rational specification for gravel concrete.

The need of such a specification is very great. It is estimated that of concrete construction the country over, at least 50 per cent is of gravel aggregate.. No one can doubt that this concrete is average good quality. Were it not, gravel would have ceased to be used so extensively. It is plain, too, that many compositions of gravel must have been used, for gravel deposits are very variable and the local deposit is the one commonly utilized. The conclusion is that a great many compositions of gravel make good concrete. But the usual specification which lumps gravel and broken stone in one class as coarse aggregate does not harmonize with this conclusion. It is fundamentally a broken stone aggregate specification, and as a gravel aggregate specification it is both too lenient and too exacting. Oftentimes an inferior gravel will meet the requirements while a superior gravel will be condemned. The reason lies in failure of sand-broken stone aggregate requirements to take cognizance of the greatly different and much more intimate relation in sand-gravel aggregate between the fine and the coarse particles. Determination of this relation will come from the studies now in progress, it is hoped, and then a rational specification for gravel concrete can be formulated.

ARE ENGINEERS IMPROVING AS PUBLIC SPEAKERS?

The engineering profession has long been "vocal in spots." The spots are rapidly growing larger and more numerous. The average engineer is less backward in coming forward with his ideas on a great variety of topics of community interest than he was a decade ago. He has taken thought as to the advisability of improving himself as a public speaker and already there is a great improvement among engineers in this particular.

There was a time, not so long ago, when many engineers introduced their remarks with an apology. When called on to speak extemporaneously the engineer usually prefaced his remarks by saying: "I'm not much of a speech-maker, but—" Then he went on to prove it and proved it so thoroughly that his auditors were conscious of little else. What he had to say was worth saying, but in saying it he encountered the rub. Perceiving, finally, that he was appearing to poor advantage among other professional and business men he quit thinking that he could not talk. He came to realize that he could talk in public and that he must talk or deliberately and finally abandon the hope of filling the position in the life of the community to which his mentality entitled him.

We fancy that the public does not expect the engineer to talk after the fashion employed by lawyers of this and past generations. The public will no doubt feel much obliged to the engineer if he continues to differ at many points with the lawyer—the more the better. Oratory is decadent and the present sophisticated generation does not react to it. No man has a right to indulge in oratory, nowadays, unless he first pays the hall rent. We call attention to this for the reason that the engineer should not feel that he is not getting on as a public speaker because he eschews ornate language. He is expected to speak clearly and forcefully, with both precision and accuracy, and in non-technical language whenever and so far as that can be done without weakening his argument. Judged by these standards he is making very gratifying progress.

THE ENGINEERING TEACHER'S DUTY TO THE ENGINEERING JOURNAL.

At times the editor's imagination soars to the task of directing a school of engineering. He would in such an improbable contingency have taught mathematics, physics, English and the habit of study. His opinion varies from time to time about having anything else taught, but generally it is that he would not. He would have instead more teaching of the habit of study. And in a little while he would probably lose his job. Seriously, however, to learn to study habitually is one of the greatest acquirements that can come from university training, and to teach the habit of study is one of the greatest benefits that a university training can bestow.

Most teachers of engineering, we believe, endeavor to inculcate the habit of study. In general they are successful so far as the student's practice in college is concerned. Without fairly habitual study graduation with moderate ranking is impossible in our better engineering schools. But does the teacher of engineering do all that he might to engraft the habit of study so strongly that it will persist in the years following graduation? Does he urge with the force that its importance warrants the necessity of a determined purpose to continue study after graduation? Does he point out ways and means for such study? Some teachers of engineering do all of these things purposefully. A great many others do them only perfunctorily. Asked what warrant we have for these assertions the reply is: First, inquiry among engineering graduates discloses few who recall particular effort by their teachers to impress upon them the vital importance of habitual after-college study; second, the editors' observation as purveyors of after college courses of study indicates that the habit of such study is not common.

The conception of the engineering journal as a medium for imparting after-college instruction in engineering is presented in the final assertion of the preceding paragraphs. We wish to direct particular notice to this idea. It has been often announced and so is a novelty only in the sense that it has not been commonly grasped by those most concerned in its possession. Among those interested persons the teacher of engineering stands at least second if not first in his need of possession. The interest which every good teacher has in the after-school success of his "boys" is one reason. The concern which he has in the reputation of his college and of himself as a teacher, a reputation that is made by the after-school accomplishment of the graduates, is another reason.

It will have been comprehended by those who have followed so far, that the object toward which the present writing is directed is the support by the teacher of engineering of the engineering journal as a medium for purveying after-college instruction in engineering. Obviously the sufficiency, or at least the efficiency, of the engineering journal as a medium for the purpose stated is the first determining question to be settled. Premising that the editor speaks with proper embarrassment, the assertion is made somewhat confidently that nowhere is there offered a medium so efficient at so small an expense. Indeed, it is felt that considerably greater praise than this is warranted, but elaboration of proof is forbidden by space and has less than full force when proceeding from the interested party. This task, we believe, in so far as its performance concerns the engineering school student, is the duty of the engineering school teacher.

As has been indicated, the engineering journal considers that it is warranted in asking this service by the personal concern of the teacher of engineering in advancing means for the continued development of the work of his hands. But also it is felt that the service is deserved on a quid pro quo claim. The engineering journal has been a strong force, for many years, upholding the hands of the engineering school and of the teacher of engineering.

MAKING AVAILABLE GENERAL INFORMATION OF USE TO BIDDERS.

The ordinary set of highway bridge plans shows a rather pictorial general plan and elevation of the entire structure and a collection of detailed plans, elevations and sections of selected parts of it. In general, these drawings are presented in sufficient detail to enable the bridge to be built substantially as planned by the designer. Accompanying and supplementing these plans there is a set of specifications intended to cover those items which are essential to the letting of the contract and the building of the structure, but which are not covered by the plans. The information given in these specifications varies greatly and depends somewhat upon the viewpoint of the designer. Too often, however, the importance of brevity and definiteness in specifications is overlooked, and clauses which are not essential are included simply because they are readily available from other sources. But, in general, the plans and specifications fairly well meet the needs of the actual builder. However, the full purpose of the designer should be to secure a satisfactory structure at the lowest price that it can be built by an efficient and honest contractor and still leave the latter a fair profit. If the designer seeks to secure more or less than this he is endangering the entire project.

To secure the best results it is essential that there be presented, as a part of the plans and specifications, such information as will enable the prospective bidder to appreciate the conditions under which the work is to be done. Evidently the average designer does not fully recognize the importance of doing this, but takes the attitude that it is up to the bidder to obtain this information for himself. It is obvious that such an attitude tends to promote guesswork and is harmful to all interests concerned.

We have recently had occasion to examine a set of plans for a reinforced concrete highway bridge which deserves commendation, mainly because the designers have anticipated to such an extent the needs of bidders. We refer to the plans for the proposed Webster St. bridge over the Mad River at Dayton, Ohio. Instead of giving a general and vague description of conditions, as is sometimes done in the preface of specifications, the designers have here included in the plans rather complete information in compact form. For example, there is shown, in addition to the customary general plan and elevation of the structure, an additional sheet which contains: a sectional elevation indicating subsoil conditions and giving the results of borings; a plan showing in detail the locations of the old and new piers and of the shore lines, property lines, etc.; and last, but not of least importance, a large-scale map of the bridge site and of the surrounding territory showing the location of streets, main and spur railway tracks, vacant properties which may be utilized by the successful bidder, etc. Another sheet shows, by means of curves, the gage heights and fluctuations of the river covering each of the previous 23 years, together with a curve showing the mean daily temperatures for a term of years.

In the case cited some of the information was collected previously, as the result of an elaborate survey of general flood conditions, but the point we wish to make is that those in charge of the design have made full use of this and other information of vital importance to bidders. The more general inclusion in bridge plans of information similar to that outlined above is greatly to be desired, as it is an important factor in eliminating guesswork on the part of contractors.

A PREACHMENT AGAINST USING OFFICE BUILDING NAMES FOR ADDRESSES.

If there isn't a well organized sentiment against the use of an office building name, in place of street and number, in giving out one's address, there ought to be. The editor has long held this view and felt very lonely in it until he read a brief editorial on this subject in a recent number of the Saturday Evening Post. That editorial pointed out that New York City had learned that strangers are always in town and that they are greatly helped in finding their way to a man's office if it is down in the various directories as number so and so in such and such street rather than in the Blank Building. If only the name of the building is given, as is the rule in many large cities, this must be located by street and number before the stranger can find the man he wishes to see. This leads to numerous petty annoyances and occasions loss of time to no good end whatsoever.

One can understand why the owner of an office building gives it a name—that is natural enough. Only the use of that name by the public in place of street and number is objectionable. Knowing the names and locations of the numerous office buildings in our large cities easily classes as superfluous information. Why clutter up our heads with such useless knowledge when there are so many things worth knowing that we cannot hope to learn?

Engineers and contractors have only the general interest of the citizen in this subject. They can, however, help their out-of-town clients by using street and number instead of the name of an office building in giving out their addresses for use in directories and on their own letterheads.

EDITORIAL PARAGRAPHS.

A clever writer has recently criticized a great public official for being unable to "conceive himself as acting upon any motives that are less than seven feet high." It would be painful for this official, says his critic, "to admit that his motives at any particular time were less high than they had been at some other time." To attribute to one's own activities always the highest of high motives is a common human fault. Engineers are somewhat given to its commission in specification writing.

In a recent litigation over a paving contract, that has come to our notice, a prominent engineer acting as expert witness, in criticizing a certain extremely rigid specification announced: "It enables the engineer to heckle any contractor into bankruptcy." Being shown that the requirements thus condemned were quoted from a specification originally written and employed by the expert himself and being asked to explain the apparent contradiction of criticism and practice the reply was: "I intended it to be a weapon to be used only when my judgment indicated the necessity." Verily much unction comes from the certainty always of one's seven-foot motives.

A movement is on foot to urge creation by Congress of a permanent commission to apportion expenditures for river and harbor work, removing this task from the jurisdiction of Congress itself. It is announced that behind this movement are Secretaries Redfield, Houston and Lane and Senators Ransdell and Newlands. This announcement is interesting. However, success in Congress of the plan is contingent upon thinking in terms of the nation and very few congressmen are capable of this.

Apropos of the decision, printed in another column, of the Chief of Engineers, U. S. A., against the proposed $5,000,000 Illinois waterway, Mr. Joy Morton, a prominent promotor of the project, says: "The matter of tolls is nothing for the engineer to concern himself with." In other words the engineer should remain in his place as hired technician and not concern himself with broad affairs of business economics. The Illinois waterway deserves stronger defense than this.

Mr. Louis D. Brandeis, best known, at least until recently, to newspaper readers as the man who announced that by efficiency methods the railways of the United States could save a million dollars a day, should be pricked in all his sensitive parts by the manner of the proceedings before the Senate Committee charged with the task of determining the extent of this gifted lawyer's judicial temperament. There has been a waste of at least a million words a day until now and the discussion is still going strong.

Various and often curious are the forces that instigate public improvements. Not a day's journey distant is a town noted widely as a settlement of the greatly rich. Luxury and beauty characterize its homes. But none of this is evident to the stranger arriving by railway; only a short street or two bordered with small shops and wooden houses of tradesmen. In a day not long past there came to this town from the Knickerbocker grants a lady whose recognition is as that of royalty in creating the social standing of its recipients. Arriving and thrice graciously welcomed by her hostesses, she stood agaze. "Looks like Red Dog, Arizona," was the abrupt comment. My dear, you should have seen their faces! And now much money has been subscribed and the little shops have been bought and a business street designed by a famous architect is being built. Pavements and parkways and colorful shops in Elizabethan brick and stucco, instead of stamped iron fronts and shingle roofs, will hereafter greet the eyes of arriving strangers.

PRACTICAL SELECTION OF AGGREGATES FOR CONCRETE.

To the Editors: The writer begs leave to make a correction in the article he submitted you and which was published in your issue of Feb. 16. The last paragraph, p. 173: "Sieves of 4 mesh, 14 mesh and 40 mesh be used, 100 per cent to pass No. 4, not less than 70 per cent to pass No. 14 mesh, not less than 20 per cent or more than 30 per cent to pass No. 40 mesh."

The voidage spoken of, p. 172, for the graded gravels is the loose voidage measured by pouring into container checked or weight and specific gravity.

Very truly,
R. J. BORHEK.

Tacoma, Wash., Feb. 25, 1916.

WHAT IS A SPECIAL?

To the Editors: Relative to the question raised by Mr. Earl M. Seitz, in your issue of March 1, as to whether cut pipe constituted a "special" in connection with the pipe line contract referred to, would say that it does not appear to me that same could be classed as a special. While the specifications may have given the approximate number of 12-ft. lengths required, it hardly stands to reason that an experienced estimator would have concluded that there would be no wastage and cutting, especially in view of the fact that it was definitely known that this pipe line would include many "specials" (castings), the locations of which are governed by features other than certain standard lengths of pipe. If the specifications for the work were at all complete, I cannot see where the contractor could claim the cutting and wastage as a "special."

Very truly yours,
J. EDWARD CASSIDY, Chief Engineer,
Foster Construction Co.

Kinney Bldg., Newark, N. J., March 2, 1916.

HYDRATED LIME ADDITION TO CONCRETE FOR ROAD WORK.

To the Editors: Your March 1 issue just reached the writer and he notes on page 206 an article entitled "Some Tests on Hydrated Lime Addition to Concrete for Road Work," which was reprinted from a report submitted by the Mixing and Placing Committee to the National Conference on Concrete Road Building.

We are very glad indeed to note the activity on your part in connection with educating your readers up to the use of hydrated lime, but we feel that the article which has been reprinted needs some explanation, and we believe this should have accompanied the article in question. Most readers of this article will be imbued with the idea that hydrated lime does not do what is claimed for it and what highway engineers have found it to do after having used it in some of their concrete road construction.

Conclusions numbers one and two state that upon the addition of hydrated lime with the water content remaining the same, that no greater freedom of movement occurred, nor did the concrete flow as well as that which contained no hydrate. The conclusions drawn are perfectly correct, as it cannot be expected that 5, 10 or 15 per cent of hydrated lime can be added to concrete and have a mass of the same consistency without increasing the quantity of water in the mix. Hydrated lime has a much greater water absorbing and carrying capacity than Portland cement and when 10 per cent of hydrated lime is added to any given consistency a corresponding amount of water should also be added to satisfy the mechanical requirements of the hydrate. If an additional 10 per cent of Portland cement were being added to a 1:2:4 mix it would be found necessary to increase the quantity of water in order to maintain any given consistency. The same holds true with an addition of hydrated lime.

The report further states that it was found that hydrated lime did prevent segregation. The point the writer desires to make is that hydrate will carry into the mixture a greater amount of water without segregation than will be carried by concrete which contains no hydrate. These must be the final conclusions drawn after an analysis of the report in question and it will further be realized that this is a point of considerable value.

Much has been said recently about the quantity of Portland cement which hydrates in concrete, and while authorities differ as to the actual amount hydrating, they do, however, all agree on one thing; that is, that a considerable portion of the Portland cement in concrete does not hydrate. This is probably due to the fact that there in an insufficient amount of water retained in the mixture to cause further hydration. It is pointed out above that hydrate carries an additional amount of water into the concrete, and it is therefore to be supposed that this additional water will aid in bringing about further hydration of the cement, consequently an increase in strength.

The writer firmly believes this matter should be taken up and pointed out in your next issue in order that correct conclusions may be drawn from the article you have just printed.

Yours very truly,
HYDRATED LIME BUREAU,
Norman G. Hough, Mgr.

Pittsburgh, Pa., March 2, 1916.

COMMENT ON THEORETICAL DETERMINATION OF BENDING MOMENT AND DEFLECTION IN COLUMNS.

To the Editors: After perusing the article, in your Feb. 2, 1916 issue, by Mr. David Kaplan, on the theoretical determination of the bending moment and deflection in columns, and supplying the omitted steps necessary for the derivation of formulas (3), (4) and (4a), I came to the conclusion that the very assumption is erroneous.

The main assumption made is that $y = x^n$ where x is a variable and n some unknown exponent. No mention is made whether n is constant or variable.

Now if I assume n constant and integrate accordingly I arrive at the very same formulas given in the article; therefore my assumption must be the one originally made. Let us now try to get these formulas according to the assumption stated, namely, $y = x^n$.

$$M = \frac{EI\, d^2y}{dx^2} = -wy;$$

then

$$EI \frac{d^2y}{dx^3} = -wx^n \ldots\ldots\ldots\ldots\ldots\ldots (2)$$

Integrating with respect to x (n being assumed constant),

$$EI \frac{dy}{dx} = \frac{-wx^{n+1}}{n+1} + C \ldots\ldots\ldots\ldots\ldots (1)$$

but we are directed to make $\frac{dy}{dx} = 0$ when $x = l$,

$$EI \frac{dy}{dx} = \frac{-wx^{n+1}}{n+1} + \frac{wl^{n+1}}{n+1} \ldots\ldots\ldots (2a)$$

Integrating (2a) with respect to x (n being constant)

$$EIy = \frac{-wx^{n+2}}{(n+1)\ (n+2)} + \frac{wl^{n+1}}{n+1} x + C_1 \ldots (2b)$$

but as we are further directed to make $y = 0$ when $x = 0$, therefore $C_1 = 0$, and (2b) becomes,

$$EIy = \frac{-wx^{n+2}}{(n+1)\ (n+2)} + \frac{wl^{n+1}}{n+1} x \ldots (2c)$$

Substituting x^n for y in equation (2c):

$$EIx^n = \frac{-wx^{n+2}}{(n+1)\ (n+2)} + \frac{wl^{n+1}}{n+1} x \ldots (2d)$$

Putting l for x in order to find the center deflection, we have,

$$EIl^n = -\frac{-wl^{n+2}}{(n+1)\ (n+2)} + \frac{wl^{n+2}}{(n+1)}.$$

Clearing fractions and dividing by l^n, there results,

$$EI\ (n+1)\ (n+2) = -wl^2 + wl^2\ (n+2), \text{ or}$$
$$EI\ (n+1)\ (n+2) = -wl^2 + nwl^2 + 2wl^2, \text{ or}$$
$$EI\ (n+2)\ (n+1) = +wl^3\ (n+1), \text{ or}$$
$$EI\ (n+2) = +wl^2$$
$$n = \frac{wl^2}{EI} - 2, \text{ and}$$
$$M = wx^{(wl^2 \div EI - 2)} \ldots\ldots\ldots\ldots\ldots\ldots (4)$$
$$y = x^{(wl^2 \div EI - 2)} \ldots\ldots\ldots\ldots\ldots\ldots (4a)$$

These results agree with the formulas in the said article.

Now let us turn to equation (2d). For a given w, l, E and I, n varies as x, or n is a function of x, which means that the assumption $y = x^n$, in which n is constant, is ridiculous.

That the assumption in the article is incorrect can be established in another way, which, though wanting in rigor, still is one which common sense asserts.

Can it be conceived that by a mere substitution of one variable for another and with the application of the calculus we can arrive at truth unknown before?

No new conditions being imposed, the obscurity of truth cannot be penetrated with the aid of mathematics. There is nothing in the article that was previously unknown, and no new results can be derived.

Very truly yours,
M. Gordon.

154 Nassau St., New York,
Feb. 7, 1916.

FURTHER COMMENT ON THEORETICAL DETERMINATION OF BENDING MOMENT AND DEFLECTION IN COLUMNS.

To the Editors: Referring to the article contributed by Mr. David Kaplan on the theoretical determination of bending moment and deflection in columns, which appeared in your issue of Feb. 2, 1916, I hereby wish to point out the fallacy of the entire discussion.

The author virtually claims to have discovered the exact mathematical interpretation of column action: that which Euler, Rankine, Gordon and many other great scientists could not obtain. The most remarkable thing about this article is that the author does not introduce any new ideas, but simply uses Euler's formula, making it a great deal less "obstinate" by equating y to some unknown power of x. This is the only new "idea," but the trouble with that idea is that it is as fallacious as it possibly could be. The author by writing, for the deflection at any point in terms of x, $y = x^n$, where n is a constant, assumes at the very outset that the elastic curve in a column belongs to the parabolic family of curves. If the elastic curve does not belong to the parabolic family of curves, and we know that it does not, then it cannot be represented by the above equation for the simple reason that for any other curve n must be a variable.

Let us take as an example the equation of a circle $x^2 + y^2 = R^2$ and equate y to x^n. We have then $x^2 + x^{2n} = R^2$ and, solving for n, we get

$$n = \frac{\log (R^2 - x^2)}{2 \log x},$$

which shows that n varies with x, and cannot be a constant. Similarly any other curve not belonging to the parabolic family cannot be represented by the equation $y = x^n$, where n is a constant.

If the result at which the author arrives by substituting in the equation,

$$EI \frac{d^2y}{dx^2} = -Wy \ldots\ldots\ldots\ldots\ldots\ldots (1)$$

x^n for y were correct, we should certainly obtain the same result by making that substitution after integration. Integrating equation (1) twice we get Euler's result,

$$y = f \sin \left(\frac{W}{EI}\right)^{\frac{1}{2}} x \quad \ldots\ldots\ldots\ldots\ldots (2)$$

where f is the maximum deflection of the column. If we now substitute x^n for y we have from equation (2),

$$x^n = f \sin \left(\frac{W}{EI}\right)^{\frac{1}{2}} x \quad \ldots\ldots\ldots\ldots\ldots (3)$$

Solving equation (3) for n we get,

$$n = \frac{\log \left\{ f \sin \left(\frac{W}{EI}\right)^{\frac{1}{2}} x \right\}}{\log x} \quad \ldots\ldots\ldots (4)$$

which proves conclusively that n is a variable. This overthrows the author's theory, which is based solely upon the assumption that the exponent of x in his equation $y = x^n$ is a constant. The fallacy of the author's theory is so much more evident from the analogy which he draws between his equation (4a) and the deflection in a simple beam loaded at the center, when $(Wl^2 \div EI) = 3$, making n in his equation (4a) equal to 1. For this case his equation (4a) becomes $y = x$, a straight line making 45° with the axes of ordinates, while in a beam we have

$$y = \frac{2x^3}{L^2} - \frac{3x}{2},$$

which does not seem to resemble a straight line equation.

Very truly yours,
Harris Epstein.

154 Nassau St., New York,
Feb. 7, 1916.

COMMENT BY AUTHOR ON THEORETICAL DETERMINATION OF BENDING MOMENT AND DEFLECTION IN COLUMNS.

[Copies of the two preceding letters were submitted to the author of the article in question, who replied as follows.—Editors]:

In connection with my article on "The Theoretical Determination of the Bending Moment and Deflection in Columns," published in your issue of Feb. 2, 1916, permit me to add the following demonstration, without which the fundamental assumptions at the outset of the article may lead to misinterpretation.

Referring to Case 1 of my article, the two equations, $y = x^n$, and $M = EI \frac{d^2y}{dx^2} = Wx^n$ (in which the power n was assumed to be constant), could not have been formed upon the condition that the bending moment in a column due an axial load W is equal to the load times the deflection produced by it at the given point. For in that case we could write:

$$EI \frac{d^2y}{dx^2} = \pm Wy, \text{ where } y = \pm f(x), \quad \ldots\ldots\ldots (1)$$

$$\frac{dy}{dx} = \pm f_1(x) \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

$$\frac{d^2y}{dx^2} = \pm f_2(x) \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (3)$$

Multiplying both sides of equation (3) by EI and equating it to the bending moment we get:

$$\pm EIf_2(x) = \pm Wf(x) \text{ or } \frac{f(x)}{f_2(x)} = \pm \frac{W}{EI} = \text{a constant} \ldots (4)$$

But in equation (4) the ratio of the two functions of x can only be constant when it is equal to ±1, i. e., when $f(x) = \pm f_2(x)$, which is indeterminate and is only true for the curve of sines, as derived by Euler.

It follows from the above that the assumed condition of column bending, i. e., that the bending moment at any point in a column is equal to the axial load times the deflection produced, is indeterminate, and that for any elastic curve the deflection at any point in a column may be assumed either greater or less than the value of y in the expression for the bending moment Wy for that point.

Under the above assumption we may, therefore, write the expression Wx^n as given in article, since x^n is assumed to be greater or less than the deflection produced by the bending moment Wx^n, and, therefore, satisfies the elastic curve.

By twice integrating Wx^n, as in the article, the expression for the maximum deflection at the center of the column was obtained in terms of l and n, or

$$d = \frac{Wl^{n+2}}{EI(n+2)} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (5)$$

But as reasoned above the maximum deflection is either greater or less than the value of l^n in the maximum bending moment Wl^n, hence:

$$\frac{Wl^{n+2}}{EI(n+2)} = Kl^n, \text{ where K is either greater or less than unity} \quad \ldots\ldots\ldots (6)$$

Solving the above equation for n, we get:

$$n = \frac{Wl^2}{EIK} - 2 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (7)$$

An analysis of equation (7) indicates that for K less than unity the value of n and hence of the bending moment Wl^n is greater than for K greater than unity. On the other hand, from equation (6), when K is less than unity the deflection is less than when K is greater than unity. In other words, the above equations though theoretically correct lead us to the absurdity that a greater bending moment produces a lesser deflection.

The fundamental assumption in my article that the power n is a constant for the condition that the bending moment at any point in a column is equal to the axial load times the deflection produced by it, although not satisfying the elastic curve, is, therefore, logically correct, and the results derived are in all probability true.

In conclusion, I wish to mention a discovered fact with reference to the enormous deflections obtained in the table of my article by assuming the ultimate loads for the several sections about axis Y-Y (according to Gordon's formula), particularly for the 12-in. 31½-lb. I-beam. In checking the ultimate load for this beam for the free-end condition, by Euler's formula, which is applicable to long columns, the ultimate load was found to be 48,150 lb. instead of 111,000 lb., and necessarily the deflection reduced from 31,806,700 in. to only 7.95 in., the same being true for the other enormous deflection values.

The above is merely an additional proof as to the amount of reliability of empirical expressions.

Very truly yours,
David Kaplan.

607 Snediker Ave., Brooklyn, N. Y.

SAND-TAR COATING TO PREVENT SLIPPERINESS ON MACADAM ROADS.

To the Editors: In your issue of Feb. 16, 1916, an article by Mr. B. P. Harrison, entitled "Methods of Remedying Slipperiness on Surface Treated Macadam Roads in Maryland," offers a moderate-priced solution for slipperiness.

The writer has had occasion several times since 1912 to use this method of coating to prevent slipperiness on bituminous mecadam grades. The first experiment in Maine in the fall of 1912 was successful. In the following winter a special resolve was passed by the State Legislature to treat the grades on a 5-mile stretch of bituminous macadam. As a result some 21,000 sq. yd. were treated with the mixed sand and tar.

The Street Superintendent of Hingham, Mass., 1914, quotes concerning his endeavors as follows: "Our method last fall, 1913, was to apply Tarvia B and sand after mixing at the yard, spreading as evenly as possible about ½ in. thick. We found it a grand success."

Providence, R. I., Worcester, Springfield and Milton, Mass., have had good results with this mixture and have found the cost reasonable. Dry sand or gravel soon sweeps or washes off of a smooth surface, needing constant renewal and incidentally causing objectionable dust. In Massachusetts the question of slipperiness is a pertinent one, and such a treatment at a reasonable cost will be largely copied by road builders.

Yours very truly,
THE BARRETT CO.,
by H. C. Poore.

Boston, Mass.,
Feb. 23, 1916.

SOME FEATURES OF THE DESIGN OF COMBINED AND STORM WATER SEWERS.*

By E. S. Spencer, Department of Public Works, St. Paul, Minn.

Location.—In laying out a system of sewers, the best location and arrangement is either determined at once by the exigencies of the situation, or in most cases may be selected after trial estimates of a few of the more likely arrangements in order to find the most economical.

The essential thing is to define the limits of the watershed within which the sewers will lay, and further, even to examine the adjacent territory beyond such limits in order to discover whether such territory has outlets that will be suitable for sewer lines, or must some day be tapped by an extension of the proposed sewers. Especially is this necessary in cases where it may be anticipated that disposal works will one day be required, and the time is coming, when there will be few cities in Minnesota that have not had to face the difficult problem of sewage disposal.

Run-Off.—These points being settled, the amount of water to be carried can be investigated. The perplexing subject of run-off has been exhaustively treated in recent literature. In a new locality, the estimation of run-off involves so much uncertainty, that it practically becomes a matter of making a good guess. The formulas and data available on the subject have a value which varies in direct ratio with the good judgment and experience of the engineer using them.

In a city with a permanent staff of engineers the matter of run-off must be made a permanent study, for it is of the utmost importance and only by continually watching the results of heavy rains and noting minutely every condition affecting those sewers which are just equal to their burden that a safe and economical basis of design can be derived.

In a system of sewers the laterals and small trunk sewers may very well be designed for a larger percentage of run-off than the main trunk sewers,—for the reason that there will always be some parts of the district more fully developed and yielding a greater percentage of run-off than the average over the whole district. Any small part of the whole area is subject to a rapid development but the progress of the district as a whole will be slower.

This consideration must be distinguished from the so-called retardation factor, which is briefly this: If the time taken for the water to travel from the upper end of the system to the outlet is greater than the duration of the storm, rain which falls on the lower part of the system will have passed away before the rainfall from the upper part of the district reaches the outlet. Hence, the lower end of the sewer need only be designed to carry the maximum run-off from a part of the whole area that it drains and a less amount of run-off for the remainder of the area, corresponding to a storm of less intensity and greater duration.

The average intensity of heavy storms in St. Paul is a rate of 3 in. per hour for periods not longer than 15 or 20 minutes, and only 2 in. per hour for periods lasting 40 minutes.

The retardation factor therefore may be applied to a system in which the water takes half an hour or longer to flow from the upper end to the outlet.

Size, Grade and Efficiency.—The amount of water to be carried having been estimated, the size of the sewers is next to be determined by the help of tables of capacity.

The size of the sewer and the grade at which it is laid may be assumed to determine its capacity, but they do not determine its efficiency. The depth at which the sewer is to be placed is equally important, and its depth and size are relative factors. For instance, as an example of the point I wish to emphasize, if a sewer on a steep grade is flowing just full and discharging into a river at the water level, and the river should rise 2 ft., so that the outlet of the sewer becomes submerged by that amount, a back pressure of 2 ft. will result in that sewer all the way up the hill to the last manhole and if this happens to cause a flood in the cellar of an antagonistic citizen on top of the hill, I think he would be very hard to convince that the rise in the river made the sewer too small; he would say it was the engineer. So the size and grade of this sewer did not determine its efficiency.

Sewers have one very lamentable quality. They can always be extended. Like a piece of India rubber, they will stretch if pulled hard enough and somebody is sure to apply the "pull."

So perhaps it happens that someone is led to connect a small size lateral into the bottom of a manhole on the large main sewer, in order to get sufficient depth; houses are built with basements nearly as deep as the sewer and with the first storm there is trouble.

In very flat country, where every inch of fall must be utilized, the connection of the large and small sewers sometimes becomes a problem. On the one hand, if the crowns of the various sizes of sewers are made continuous so that there shall be no back pressure, so much fall is wasted at the junctions that the grades of the sewers are not self-cleaning for dry weather flow. On the other hand, if the inverts are made continuous part of the sewers flow under pressure, and while a foot or so of back pressure may not be sufficient to reach anyone's basement, it may so reduce the hydraulic grade of a flat house connection as to make the house connection inadequate to carry the storm water from the building and in that way cause flooding of the building.

There is just one other consideration with regard to depth, I might mention in passing. Oftentimes funds are not available for building the trunk sewer as large as it should be, but if it has been placed deep enough, it can later be very economically enlarged by stripping the cover and raising the arch.

Shape.—Except under special and unusual conditions, the shape of the sewer will be either circular or egg shape, and many engineers will decide which to use off-hand. The question really merits a more careful consideration. In the days when large sewers were almost invariably built of brick, an egg-shaped sewer could be built as easily as a circular sewer, but materials and construction have changed and the circular shape is a good deal the more economical, so that the apparent advantage of the egg-shape should be closely examined. It will largely hinge on the proportion of the dry weather flow to the maximum capacity. For instance, when a circular sewer is flowing 1/10 full, that is the depth of flow is 1/10 the diameter, the discharge is a little over 2 per cent its maximum capacity and the velocity will be about 7 per cent less than if the same amount were flowing in an egg-shaped sewer of equivalent size. The difference in depth is greater and it will be somewhere about 20 per cent in favor of the egg-shape. For still smaller flows the difference in velocity is greater.

This increase, then, of velocity and depth is supposed to make the egg-shape sewer self-cleaning for conditions under which the circular sewer would not be self-cleaning. Will it do it? The most troublesome thing in a storm water sewer is sand and a slight increase in velocity of flow will not help appreciably to move the sand. In a strictly sanitary sewer the advantage of the egg-shape may be more apparent.

The depth of an egg-shaped section is 1¼ times the depth of a circle of the same area. Therefore, when we substitute the egg-shape for the circular section we lose out of the total available fall an amount equal to one-quarter the diameter of the sewer, and there are many cases where the resulting decrease in the grade will offset the hydraulic advantage of the egg-shaped sewer.

---

*Paper before Minnesota Engineers' and Surveyors' Society.

ENGINEERS AS EXPERT WITNESSES.*

By Alonzo J. Hammond, Principal Assistant Engineer, Chicago Union Station Co.

From some source I have received the impression that you all are not averse to consider the most highly efficient methods of extraction for receiving the greatest return for services rendered. This is the legitimate expression of one of three material aims in life—the other two may be to stand high in your profession and to merit and hold the respect of your fellow-man.

The professional man usually works under a handicap, in the consideration of those material elements, which make him an object of interest to the Board of Reviews or the collector of the income tax. He is so wrapped up in his technical and professional work, so enthused with new problems and new solutions of old problems, that he pays but slight heed to the commercial toll. This is inherent. It is proper, therefore, for us to consider an equality of return for the maximum of brain and energy employed in specific services. The education of an engineer in mathematics and the sciences develops a mind trained to demonstrate and prove the one correct answer for any technical problem. In his further training and development there is accentuated the desire for the most efficient analysis—the attainment of the 100 per cent. I believe this training has its effect when the engineer is retained as an expert witness.

In the presentation of evidence in a law suit, the engineer is confronted with the problem of appearing as one or a dual personality. Shall he study his case with the view of the one and correct solution and assist in keeping inviolate the infallibility of the law? Or shall he be a partisan, an advocate, and present his evidence in the most favorable light for his client, without regard for the proprieties of truth and veracity, if the story can be made plausible?

I am not bringing into question those problems to which there can be given honest differences of opinion, but those conditions where the art has reached such a stage of perfection as to dissolve all doubts. There are, however, certain relationships which on the one hand may cause disastrous results and under other circumstances produce the opposite, or no effect. It is in the presentation of such engineering data that the integrity of the witness is brought into the limelight.

As experts in court proceedings, we have most prominent in the public eye the medical profession, but so much contradictory testimony has been presented in numerous celebrated cases that it is not at all infrequent to hear expressions of courts favoring the employment of such experts by the judge. The expert would then act merely in an advisory capacity to the court, and his evidence would be strictly exparte.

We have had in the various professions, particularly in the larger cities, men prepared to appear as experts in any case which may arise, and this has been so for many years. In the engineering profession such experts have developed in more recent years. Now some of these men are ready to prepare the technical side of a case, developing the testimony, arranging the questions and the answers, and submit the whole for recital prior to appearance on the witness stand, so that it can be thoroughly rehearsed and the effect on the judge and jury considered in advance of its presentation. This is all a logical, businesslike procedure, and appeals to the combative spirit of the attorney, whose moral code is bound up in any course to win the case for his client. This procedure is also in line with what has been the practice with other professions, particularly the medical, for many years.

Twenty-five years of engineering practice, covering a wide range of corporate work, public, public service, and private engagements, have given the speaker opportunity to appear frequently in court proceedings. Some engagements have extended over long periods of time and covered the preparation and presentation of a mass of evidence. To the credit of the engineering profession, I wish to observe in passing that in only two cases has it been apparent to me that engineers have stultified themselves in giving evidence in support of their clients' claims.

In my opinion, the position of the engineer expert should be that of the technical adviser of the court. His duty to his client may require all his ability and enthusiasm in the development of the case, but the limit is in the honorable presentation of evidence which he thoroughly believes can be fully substantiated.

Another interesting phase of this subject, which is apropos and should be touched on, and may be of peculiar and particular interest to you, is that of compensation. We are accustomed to the practice of a per diem rate, varying with the skill and experience of the engineer, but we have yet to reach the practice of the legal and medical profession of charging in proportion to the client's ability to pay. The retainer is infrequent and the charge for preparation is not sufficiently considered. We have been too modest—the profession is young, and perhaps it has become us well to be modest, but it is opportune that with the varied development of modern enterprises on a tremendous scale that the brains assisting in maintaining a statu quo, or proving up certain rights, should be recompensed in proportion to their magnitude.

Distributoin of Pressure Through Soils.—A series of experiments on the distribution of pressures through soils are to be conducted by the Office of Public Roads and Rural Engineering, U. S. Department of Agriculture. A specially designed apparatus will be installed which will permit of earth pressure measurements being taken in a large number of positions during a single application of the load. This feature is regarded as an important one and it is hoped that an unnatural rearrangement of the soil from previous load applications in various positions will be thus avoided. Earth fills up to 10 ft. thick may be accommodated by this apparatus and it will have lateral dimensions sufficiently large to permit of obtaining the full distribution of the load in all directions. Very comprehensive plans have been made for a practical solution of this problem and it is hoped that definite results will be forthcoming within a short time. The uncertainty of the distribution of pressures through soils, both vertically and horizontally, has long been recognized by the engineering profession, and several isolated experiments have been made with laboratory apparatus to gain knowledge on this subject. In magnitude, the problem is such that its practical solution can be attempted only by the most thoroughly equipped experiment stations. In application, the final solution will be important to all branches of engineering, and it has seemed desirable that the Department should devote a portion of its experimental resources to a most thorough and conclusive research of this nature.

Profit Sharing and Pensions for Asphalt Employes.—The General Asphalt Co., of which the principal subsidiary is the Barber Asphalt Paving Co., has notified its employes of the adoption of a profit-sharing plan and pension system. The division of profits will be on the basis of 1 per cent of the annual salary of each employe for each $100,000 of net gain to surplus over and above the amount required for the 5 per cent dividend on the company's preferred stock. This dividend requires $652,705 per annum. Pensions are to be paid at the rate of 1 per cent of the average salary during 10 years preceding retirement multiplied by the number of years of service. In the case of an average salary of $2,000 and 25 years of service the yearly pension would be $20, multiplied by 25, or $500; this is $41.66 per month.

---

*Abstract of address before the Associated Technical Men as published in The Technician for February, 1916.

AN UNUSUAL AND EFFECTIVE FORM OF PIER DERRICK.

Contributed by Herbert Vanderhoof, Chicago, Ill.

At Prince Rupert, the most northern of the Canadian ports on the Pacific, the Grand Trunk Pacific Ry. has placed in operation its new 20,000-ton dry dock, which cost about $2,000,000. This dock is equipped with a special pier derrick designed to handle all classes of material, such as machinery, boilers, guns, tanks, etc., between the railway cars on the pier and vessels. The capacity of this derrick is 50 tons at a reach of 40 ft. from the face of the pier. Figure 1 is a view of the derrick taken during the construction of the pier.

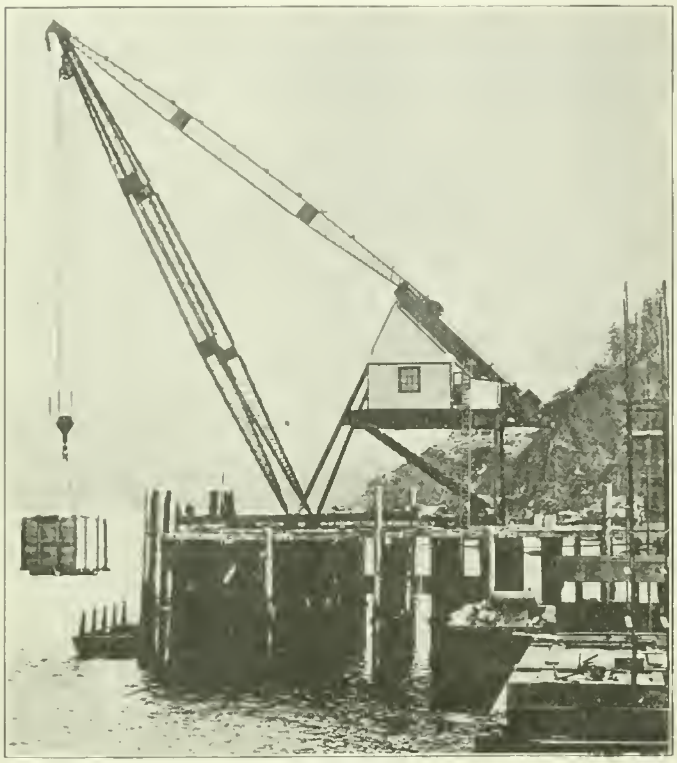


Fig. 1. View of Novel and Effective Pier Derrick at Dry Dock of Grand Trunk Pacific Railway, Prince Rupert, Canada.

The main hoisting tackle consists of an eight-part, 1⅛-in., plow steel hoisting cable running over 32-in. sheaves and wound up on 30-in. drums. The hoisting speed of the hook is 10 ft. per minute when hoisting 50 tons, or 20 ft. per minute when hoisting 20 tons. The small auxiliary fall consists of a three-part tackle of ⅝-in. steel hoisting cable running over 18-in. sheaves and wound up on a 16-in. drum. The auxiliary hoist has a capacity of 5 tons when hoisting at a speed of 40 ft. per minute.

The main A frame, or sheer legs, is about 112 ft. center to center of pins, and these sheer legs are pivoted at the lower end about 1 ft. 3 in. from the face of the pier so that when they stand vertically the load can be swung in this distance from the pier and landed approximately in the center of the railway car.

The most interesting feature about this pier derrick is the manner of topping up and operating the sheer legs. As is shown in Fig. 1, a steel strut about 97½ ft. long is connected at its upper end to a top or outboard pin of the sheer legs, and the inboard end of this strut is connected to a traveling carriage which is operated by a long, heavy screw supported by the structural portion of the derrick. This screw is 6 in. in diameter and is fitted with a heavy nut of phosphor bronze, about 18 in. long, which is carried in a trunnion with steel gudgeons, the latter taking the forked end of the above mentioned strut. This trunnion forging is supported at its outer end by two 33-in. car wheels, which run on a track along the top of the steelwork. A 52-hp. motor is used for turning the screw, which in turn raises or lowers the sheer legs.

A 52-hp. motor is used to operate the main 50-ton hoist, while a 22-hp. motor is used for the 5-ton auxiliary hoist.

The electrical equipment operates on alternating current at 550 volts, 25-cycle, 2-phase.

COST OF SPADING AND RAKING A SMALL PARK.

Contributed by H. R. Ferriss, 203 Times Block, Victoria, B. C.

Following is the cost of spading and raking a small triangular park containing 1,700 sq. yd., preparatory to planting to grass:

		Cost per 100 sq. yd.	
Spading: Foreman, 9 hr. at 35 ct.	$ 3.15	$0.185	
Labor, 170 hr. at 20 ct.	34.00	2.000	
			$2.185
Raking: Foreman, 6 hr. at 35 ct.	$ 2.10	$0.124	
Labor, 140 br. at 20 ct.	28.00	1.647	
Cart and horse, 6 hr. at 65 ct.	3.90	.230	
			$2.001

All grading had been completed and the surface dragged and roughly leveled before spading was started. The soil, the character of which has considerable bearing on the cost of this kind of work, was a dense clayey loam thickly sprinkled with small stones. The entire area was first spaded and then raked; all the stones, clods, etc., gathered into piles and picked up by the driver of the cart. The cost of preparing the park, though apparently high, is in reality close when the character of the soil and the small area is considered. About 6 cu. yd. of small stones and clods were hauled away.

CONCRETE CULVERT OF PRECAST BLOCKS.

The culvert illustrated was built at Greenville, Miss., and is 19 ft. long with an opening of 12 ins. Interlocking precast concrete blocks were employed; the block being known as the Hall culvert block. As will be observed the culvert was placed in an old roadway. This necessitated excavation to a depth of 2 ft. through "buckshot," a very heavy earth resembling adobe or gumbo. The entire operation of digging the trench, placing culvert sections, including headwalls, and backfilling, consumed the time of 1½ hours; four negroes were employed. While this

Interlocking Precast Concrete Block Culvert.

work progressed, the road was not closed for a moment, but two motor cars and three wagons passed over the structure during that time.

The culvert was manufactured by Mr. J. S. Allen, president of the Delta Concrete Culvert Co., formerly city engineer of that city, and was placed under supervision of Mr. C. R. Cox, county road supervisor. Besides the labor before mentioned, the 12-in. culvert cost the county $1 per foot at the plant. The above information is furnished by Schulz & Hodgson, Chicago, Ill.

THE DESIGN AND CONSTRUCTION OF FORMS FOR CONCRETE WORK.*

By R. A. Sherwin, Aberthaw Construction Co., Boston, Mass.

[Part I of this article, covering the general principles of form design, was published in our March 1, 1916, issue. The article will be concluded in our issue of March 15, 1916.—Editors.]

II.

Sizes and Spacings of Members.—Timber used as joists to support the floor forms are figured for the full live load of 75 lbs. per square foot plus the dead load of slab, on jobs where side-dump cars carrying a four-bag batch of concrete are used for distribution. Table I has been prepared on this basis, using the simple beam formula. This will take care of the worst case, and it places the greatest factor of safety where it is most needed.

TABLE I.—SPACINGS AND SPANS FOR JOISTS.

Slab thickness, in.		3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0	11.0	12.0
Weight, lb. per sq. ft.[1]		112.5	125.0	137.5	150.0	162.5	175.0	187.5	200.0	212.5	225.0
Size of joists, in.	Spacing of joists, in.	Span of joists in feet									
2×6[2]	18	7.2*	6.9*	6.5*	6.3	6.0	5.8	5.6	5.4	5.3	5.1
"	20	6.9*	6.5*	6.2	5.9	5.7	5.5	5.3	5.1	5.0	4.8
"	22	6.5*	6.2	5.9	5.7	5.4	5.2	5.0	4.9	4.8	4.6
"	24	6.3	5.9	5.7	5.4	5.2	5.0	4.8	4.7	4.6	4.4
"	26	6.0	5.7	5.4	5.2	5.0	4.8	4.7	4.5	4.4	4.2
"	28	5.8	5.5	5.2	5.0	4.8	4.7	4.5	4.4	4.2	4.1
"	30	5.6	5.3	5.1	4.9	4.7	4.5	4.3	4.2	4.1	4.0
2×8[3]	18	9.7*	9.2*	8.8	8.4	8.1	7.8	7.6	7.3	7.1	6.9
"	20	9.2*	8.8*	8.3	8.0	7.7	7.4	7.2	6.9	6.7	6.5
"	22	8.9*	8.4	8.0	7.6	7.3	7.1	6.8	6.6	6.4	6.2
"	24	8.4	8.0	7.7	7.3	7.1	6.8	6.5	6.3	6.1	6.0
"	26	8.1	7.7	7.3	7.0	6.7	6.5	6.3	6.1	5.9	5.6
"	28	7.8	7.4	7.1	6.8	6.5	6.3	6.1	5.9	5.7	5.5
"	30	7.5	7.2	6.8	6.5	6.3	6.1	5.9	5.7	5.5	5.3
2×10[4]	18	12.2*	11.6*	11.0*	10.6	10.2	9.8	9.5	9.2	8.9	8.7
"	20	11.6*	11.0*	10.5	10.0	9.7	9.3	9.0	8.7	8.4	8.2
"	22	11.1*	10.5	10.0	9.6	9.2	8.9	8.6	8.3	8.0	7.8
"	24	10.6	10.0	9.6	9.2	8.8	8.5	8.2	8.0	7.7	7.5
"	26	10.5	9.6	9.2	8.8	8.5	8.2	7.9	7.6	7.4	7.2
"	28	9.8	9.3	8.9	8.5	8.2	7.9	7.6	7.4	7.1	6.9
"	30	9.5	9.0	8.6	8.2	7.9	7.6	7.3	7.1	6.9	6.7

[1] Weight includes dead load of slab plus 75 lb. per square foot live load.

[2] Span which will develop 1,200 lb. per square inch fiber stress and deflection of

$$\frac{\text{Span (in.)}}{360} = \frac{48 \times 5.75 \times 1{,}200{,}000}{5 \times 360 \times 1{,}200 \times 2} = 77 \text{ in. or } 6.4 \text{ ft.}$$

$$Mr = 2 \times 5.75^2 \times 1{,}200/6 = 13{,}200 \text{ in.-lb.}$$

[3] Span which will develop 1,200 lb. square inch fiber stress and deflection of

$$\frac{\text{Span (in.)}}{360} = \frac{48 \times 7.75 \times 1{,}200{,}000}{5 \times 360 \times 1{,}200 \times 2} = 103 \text{ in. or } 8.6 \text{ ft.}$$

$$Mr = 2 \times 7.75^2 \times 1{,}200/6 = 24{,}000 \text{ in.-lb.}$$

[4] Span which will develop 1,200 lb. per square inch fiber stress and deflection of

$$\frac{\text{Span (in.)}}{360} = \frac{48 \times 9.75 \times 1{,}200{,}000}{5 \times 360 \times 1{,}200 \times 2} = 130 \text{ in. or } 10.8 \text{ ft.}$$

$$Mr = 2 \times 9.75^2 \times 1{,}200/6 = 38{,}000 \text{ in.-lb.}$$

*Deflection in this case exceeds 1/360 span.

On jobs where buggies, barrows or chutes are used for placing concrete the spacings and spans given in the tables can be increased, because the live load will be a great deal less. It is doubtful if the full live and dead loads act at the same time in any case.

The span of the joists is usually fixed by the position of the girts. The location of the latter is determined by the column spacing in a mushroom floor and by the beam spacing in beam-and-girder construction. The spacing of the joists is kept as near 24 in. as possible in order to work the ⅞-in. panel decking to the limit. With the span and the spacing known the size of joist can be selected from the tables. After the spacing of joists is determined it should be kept standard for the job so that when the panels are re-used their cleats will not interfere with the joists previously placed.

Table II gives the spacings of posts under the girts for various spans of joists and thickness of slabs. These tables were calculated for a 24-in. spacing of joists. The concentrated loads from the joists were used on a simple span in calculating the bending moment. The worst case, when one joist comes at mid-span, was used in this calculation. It will be noted that the full live load was also used in preparing this table. However, since the full live load will never get to the girt, and the span of the girt is always continuous for at least two spans, the moment of resistance of the sticks has been multiplied by 1.2.

TABLE II.—SPACING OF GIRTS IN FEET.

Slab thickness, in.		3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0	11.0	12.0
Weight, lb. per sq. ft.[1]		112.5	125.0	137.5	150.0	162.5	175.0	187.5	200.0	212.5	225.0
Size of girt, in.	[2]Span of girt, ft.										
3×6	3	12.3	11.1	10.1	9.3	8.6	7.9	7.4	6.9	6.5	6.2
"	3.5	10.6	9.5	8.7	7.9	7.3	6.8	6.4	6.0	5.6	5.3
"	4	9.3	8.4	7.6	7.0	6.5	6.0	5.6	5.2	4.9	4.7
"	4.5	6.8	6.1	5.5	5.1	4.7	4.3	4.0	3.8	3.6	3.4
"	5	5.3	4.8	4.3	4.0	3.7	3.4	3.2	3.0	2.8	2.6
"	5.5	4.3	3.9	3.5	3.3	3.0	2.8	2.6	2.4	2.3	2.2
"	6	3.7	3.3	3.0	2.8	2.6	2.4	2.2	2.1	2.0	1.9
4×6	3	16.3	14.7	13.3	12.2	11.3	10.5	9.8	9.2	8.6	8.2
"	3.5	14.0	12.5	11.4	10.5	9.7	9.0	8.4	7.9	7.4	7.0
"	4	12.2	11.0	10.0	9.2	8.5	7.9	7.3	6.9	6.5	6.1
"	4.5	8.9	8.0	7.2	6.6	6.1	5.7	5.3	5.0	4.7	4.4
"	5	7.0	6.3	5.7	5.2	4.8	4.5	4.2	3.9	3.7	3.5
"	5.5	5.8	5.2	4.7	4.3	4.0	3.7	3.5	3.3	3.0	2.9
"	6	4.9	4.4	4.0	3.7	3.4	3.1	2.9	2.7	2.6	2.4

[1] Weight includes dead load of slab plus 75 lb. per square foot live load.

[2] Span which will develop 1,200 lb. per square inch fiber stress.

For 3 × 6-in. girts, Mr = 35,000 in.-lb. = Mo × 1.2.

For 4 × 6-in. girts, Mr = 33,000 in.-lb. = Mo × 1.2.

The load on the posts is next found. This load is usually far below its allowable load as a strut, but, as has been stated, the latter may cause an excessive crushing stress perpendicular to the grain in the girt at the top of the post. It is therefore well to play safe at this point, especially where granolithic finish is to be cast with the slab. A dish in the finished floor is often caused by settlement in the panel due to this cause. A drop of ⅜ in. is not uncommon if soft wedges are used.

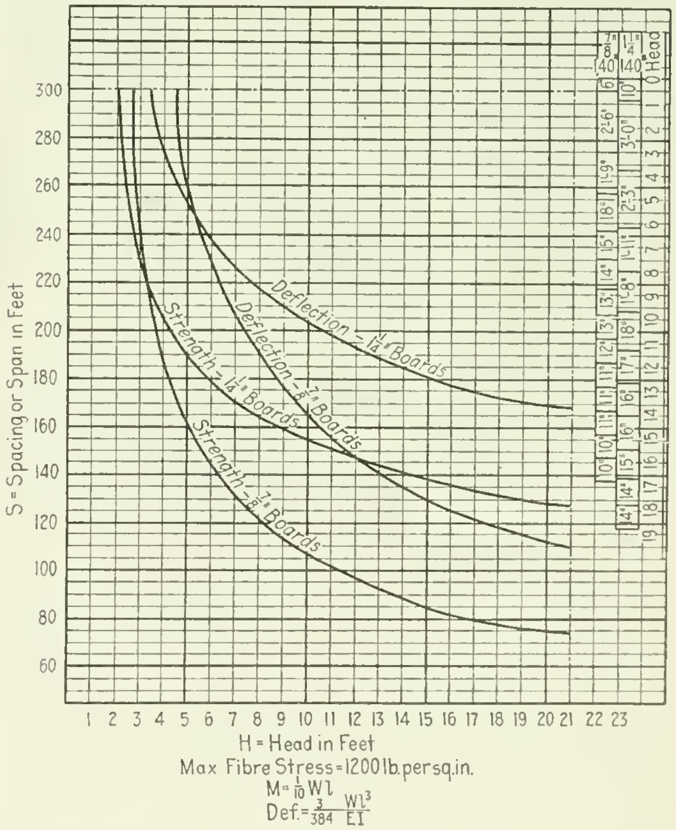


Fig. 2—Curves for Determining Horizontal Spacing of Column Yokes for Concrete Buildings.

Deflection in the floor timbers themselves need cause little worry. As will be noted by referring to the tables, fiber stress governs except in very unusual cases. When it is desirable to increase the spans given in the tables, to make a better arrangement of centering with only a slight increase in fiber stress, it is well to compute the deflection.

---

*Paper, substantially in full, presented before convention of American Concrete Institute, Chicago, Feb. 14-17, 1916.

Yokes.—Tables III and IV give the spacings of wooden column yokes for a bolt and wedge scheme. A fiber stress of 1,800 lb. per square inch has been allowed, and the load on the cleats has been determined by using the concrete at 140 lb. per square foot, water equivalent. The span of the yokes has been taken center to center of bolts, allowing 2½ in. for column sides, the thickness of the yokes, and 1 in. for wedging. This gives a greater bending moment and a heavier yoking than in some tables that have been proposed by others, the construction of which the writer has not been able to check up.

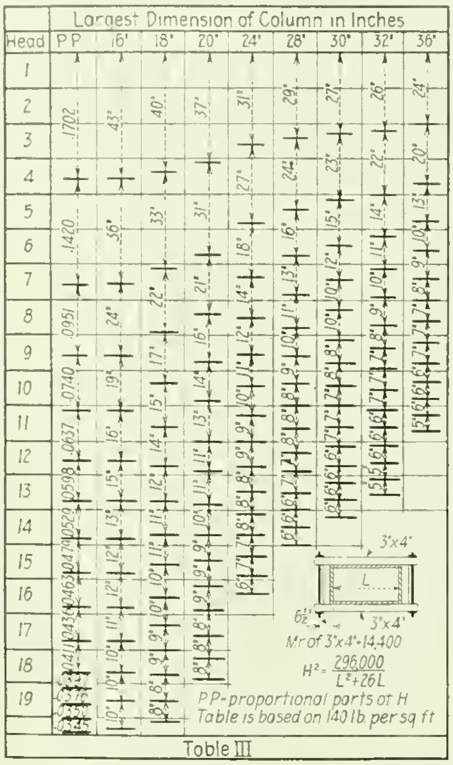


TABLE III.—SPACING OF 3x4-IN. WOODEN COLUMN YOKES FOR MAXIMUM FIBER STRESS OF 1,800 LB. PER SQUARE INCH.

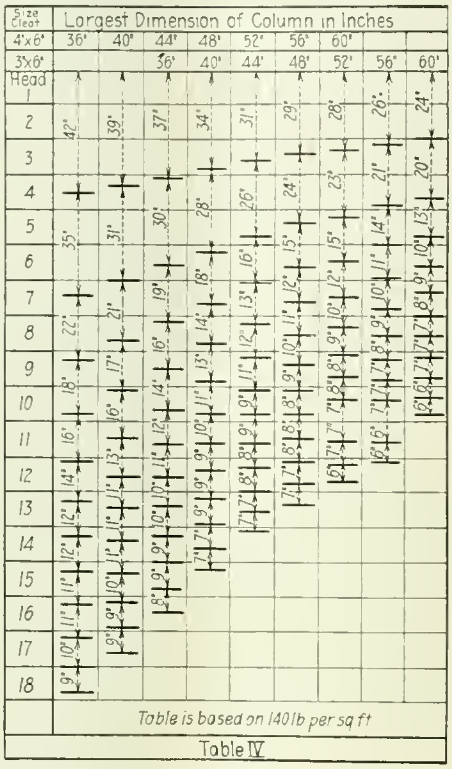


TABLE IV.—SPACING OF WOODEN COLUMN CLEATS FOR MAXIMUM FIBER STRESS OF 1,800 LB. PER SQ. IN.

For example, one well known author on concrete work in a published table gives five 2x4-in. yokes on edge for a 30-in. column with 10 ft. head. I have seen a column fail under similar conditions when yoked with seven 3x4-in. pieces. I conclude, therefore, that in making such tables the span of the yoke must have been considered as the concrete column size and a low concrete pressure used in finding the load on the yokes.

On our work we have used several styles of patented metal clamps and have always found that the manufacturer advocates a much greater spacing than we have found allowable on the job. In one case we used eight adjustable steel clamps of a certain make on a 24x24-in. column 13 ft. 5 in. high. We noted considerable deflection in the clamps. We asked the makers for their recommendation for yoking a column of this size and height and their answer was "four or five clamps would be sufficient." We had practically the same experience with another make in regard to recommendation for spacing their clamps. I believe manufacturers would do well to make some study of actual conditions before puting their products on the market.

The deflection of the column sides between the yokes will never need attention except when very large yokes are used. The limiting span for boards is shown in Fig. 2. In most cases when yokes are properly spaced for strength and for action on the bolts the spacing will be well within the limits for the boards.

A cheap method of centering a wall 6 ft. high and over is to use full-height vertical panels, heavy horizontal studs, heavy vertical liners or standards, and large rods threaded at both ends with suitable plate washers to give proper bearing for the load on the rod. By this scheme the stock can be stressed nearer to its allowable load and fewer ties used through the wall. Figure 3 gives a typical cross section for this scheme. There are so many unknowns entering into calculations for wall centering that any tables are of doubtful value. It should be noted that as a rule the head of concrete in a wall is limited by the height that it can be cast by the placing outfit in an hour. Ordinary concrete begins to set in that time so as to lose much of its hydraulic effect. Using this height and 140 lb. per square foot pressure will give safe results. It is economical when high heads occur to limit the height to which the concrete can be cast in order to use lighter forms. A system which requires a large number of rod or wire ties is decidedly uneconomical.

Drafting Room Methods.—More important to the success of the job than the values used in the calculations are the methods employed in the drafting room in turning out drawings of forms accurately and speedily. The person in charge should be experienced in the different types of concrete building construction and should have men under him who are not simply "picture" draftsmen but men whose judgment of building work is reliable. With such an organization form details can be prepared in advance in the office, leaving the job superintendent free to work out the many other details attendant upon the beginning of the job. The carpenter foreman can also use his whole energy in directing the carpenter labor, and the carpenters will need only to use their tools to assemble the panels made up in advance.

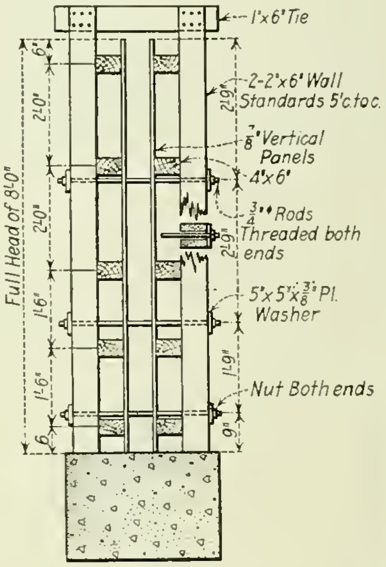


Fig. 3—Assembly of Wall Forms for Concrete Buildings.

The first study and drawings to be made form a general assembly. Usually several different combinations of timbers and methods of assembling the panels are sketched up and compared as to cost. Other things being equal, of course, the cheapest design is adopted.

A record of costs of the various units which go to make up the complete centering scheme is therefore necessary. Contractors who do not have such a record will find Taylor and Thompson's "Concrete Costs" a valuable guide in this work.

Points to be remembered in this study are:

1. Joists and girts should be in as few lengths as possible to save time in sorting on the job.
2. Use stock sizes and lengths of lumber.
3. Keep number of panels and pieces to a minimum.
4. Provide easy stripping.
5. Allow clearance enough for slight inaccuracies in making up and erecting, swelling of panels, etc.
6. Panels should be a whole number of boards in width, if possible, for ease in making up.

7. Units to be as big as can be handled and joists used as panel cleats where possible.
8. Provide for re-use of panels.
9. Beams to be handled as trough units when the job is regular and units can be re-used.
10. Consider use of floor domes or inverted boxes when beams are close together. In this way beam sides and slab are erected, stripped and moved as a unit. When either of the last two systems is used the beam sides should be given a slope to prevent hard stripping.
11. Provide for re-shoring if necessary.
12. Have bracing above the men's heads.
13. When four beam haunches occur at a column consider making haunches as a unit similar to a column head in flat-slab construction.
14. Consideration of steel forms.

Drawings.—A general assembly shows how the various parts are to be put together, supported, tied, and braced to resist the concrete pressure and the weights coming upon the members. This drawing in its final shape can be made on tracing cloth with soft pencil. The dimension arrows, lettering and figures should be inked so that clear prints can be made to avoid errors in the field. These assemblies should be filed permanently for reference on future work.

When it is necessary to strip the floor centering for re-use before the concrete has been in place long enough to gain its full strength, provisions for proper support of the green slab must be made in the design of the floor forms. The safest and cheapest method of doing this, in the writer's opinion, is to place boards between the floor panels and wedge posts up to a bearing under these boards before the centering posts are knocked out. In this way the slab is never left unsupported, as is the case when posts are replaced after all the centering is down. These boards should be placed according to a plan and shall be located so as to shorten the spans of the main reinforcing bands.

After the general scheme for the forms has been decided upon the detail panel drawings are prepared. By panel, in this paper, is meant several boards cleated together into a unit to be used as a form for some part of a concrete member. Every different sized panel is first sketched roughly on standard 6x9-in. sketching pads. These pads have holes punched at the top, so that as sketches of the different kinds of panels are made they can be bunched together and brass rivets put through the holes. These sketches are transferred in more detail onto thin tracing paper. The standard sheet is 25x33 in., divided by a 1-in space into two halves of five spaces each. These details are used at the job mill for making up the panels. The blue-prints sent to the mill man are cut up into 5x16-in. units, with one detail on each and are given to the carpenters at the making-up benches. On these detail sheets for each panel there is given the panel mark (which is stenciled onto the finished panel), the number wanted, and the floor on which they are to be used. The sizes of the stock, dimensions and alterations, when panels are to be re-used, should be clearly marked.

A system of symbols as follows is easily learned by the workmen and should be kept standard:

B, beam side; BB, beam bottoms; F, floor slab panels; P, plinth forms; H, haunch forms; C, column sides; W, wall panels.

Thus B18 means beam side number 18, and its location is shown on the key plan.

These detail sheets can be drawn up entirely with soft pencil on paper, as they are not valuable after the forms are once made. Rubber stamps for a great deal of the lettering will save time.

Where time allows and plans are complete it is advantageous to get out one kind of panel at a time. In any case the first panels to be sent to the making-up mill should be the typical floor panels. These can be used economically in building foundation walls, etc., and in this way the job can get an extra use out of them.

It is impossible to get a satisfactory cost unit for doing this form drawing. A price per square foot or per detail varies widely according to the number of details required and the number of square feet that can be made from one detail in different buildings. A big building where a large duplication of the different kinds of units is possible will cost much less per square foot for this work than a small building which is badly cut up. The average cost per sheet has been found to be about $4.50 complete. This includes time spent on studies, assemblies, key plans, scheduling, and checking. The number of sheets required on buildings of different sizes of the same type is fairly uniform according to the size. The number varies from 30 sheets on a small building up to 100 or more on a large building with irregularities. By reducing the cost of the sheets to drafting-room hours, by dividing the probable total cost by the average rate per hour, a fairly close estimate of the number of men required to turn out a job in a specified time can be made. This is useful on rush work.

The key plan mentioned above is really a diagram of the floor plan upon which are shown the locations of the various form panels. This plan is the only one which the workmen consult in erecting the form work. It must, therefore, be complete and clear.

This plan can best be made by tracing the floor plan on cloth from a blue-print, indicating the beams and holes in the floor and the columns and walls in the story below. The lines should be heavily inked and the figures large enough and spaced so that the tracing can be reduced and the photo reduced to convenient size for the foremen to handle on the job. A big blue-print is inconvenient and fades in the strong sunlight. As a rule, to avoid misun-

SCHEDULE OF
__________ FORM DETAILS
Job No.__________ Building __________ ______
Sheet No.______

Detail Number	Sheet Number	No. Reg'd	Make From	Repeat In	No. Reg'd	Make From	Repeat In	No. Reg'd	Make From	Repeat In
	Total									
	Brought For'd									
	Grand Total									

Fig. 4—Blank Form for Schedule of Concrete Form Details.

derstandings, a key plan should be prepared for each floor in the building.

The key plan may be supplemented by a letter to the job in which should be noted the assumptions made in preparing the details. These notes might include such information as clearances allowed, grades at which forms are to start, scheme for re-use, etc.

Figure 4 shows a convenient form to use in scheduling the panels. A schedule is made for each different kind of panels. This form is especially useful on a rush job where forms for one floor at a time must be completed. The additional number of each kind of panels already detailed, to be made up for each floor after the first, can be shown on this schedule.

(To be continued.)

CONVENIENT HYDRAULIC EQUIVALENTS.

Following is a list of convenient equivalents for use in hydraulic computations. Table 1 converts discharge in second-feet per square mile to run-off in depth in inches over the area.

TABLE 1.—CONVERTING DISCHARGE IN SECOND-FEET PER SQUARE MILE INTO RUN-OFF IN DEPTH IN INCHES OVER THE AREA.

Discharge in second-feet per per square mile.	Run-off in inches				
	1 day.	28 days.	29 days.	30 days.	31 days.
1	0.03719	1.041	1.079	1.116	1.153
2	.07438	2.083	2.157	2.231	2.306
3	.11157	3.124	3.236	3.347	3.459
4	.14876	4.165	4.314	4.463	4.612
5	.18595	5.207	5.393	5.578	5.764
6	.22314	6.248	6.471	6.694	6.917
7	.26033	7.289	7.550	7.810	8.070
8	.29752	8.331	8.628	8.926	9.223
9	.33471	9.372	9.707	10.041	10.376

Note.—For partial month, multiply the values for one day by number of days.

1 sec.-ft. equals 7.48 United States gallons per second; equals 448.8 gals. per minute; equals 646,317 gals. for one day.

1 sec.-ft. for one year covers 1 square mile 1.131 ft. or 13.572 ins. deep.

1 sec.-ft. for one year equals 31,536,000 cu. ft.

1 sec.-ft. for one day equals 86,400 cu. ft.

1,000,000,000 cu. ft. equals 11,570 sec.-ft. for 1 day.

1,000,000,000 cu. ft. equals 414 sec.-ft. for one 28-day month.

1,000,000,000 cu. ft. equals 399 sec.-ft. for one 29-day month.

1,000,000,000 cu. ft. equals 386 sec.-ft. for one 30-day month.

1,000,000,000 cu. ft. equals 373 sec.-ft. for one 31-day month.

1,000,000,000 United States gals. per day equals 1.55 sec.-ft.

100 United States gallons per minute equals 0.223 sec.-ft.

1 in. deep on 1 square mile equals 2,323,200 cu. ft.

1 in. deep on 1 square mile equals 0.0737 sec.-ft. per year.

1 cu. ft. of water weighs 62.5 lbs.

1 HP. equals 550 ft.-lb. per second.

1 HP. equals 1 sec.-ft. falling 8.80 ft.

$1\frac{1}{3}$ HP. equals about 1 KW.

To calculate water power quickly: $\dfrac{\text{sec.-ft.} \times \text{fall in feet}}{11}$ = net horsepower on water wheels realizing 80 per cent of theoretical power.

Salesmen Conventions.—The biggest convention of salesmen ever held will take place in Detroit, Mich., July 9 to 13, of this year. The World's Salesmanship Congress, which will be the first of a series of annual conventions, has for its purpose the placing of salesmanship upon a scientific basis, the training of salesmen and the furthering of proper sales management. A number of the greatest sales authorities in the world will take active part in the convention. D. M. Barrett is general chairman of the congress.

APPARATUS FOR MEASURING THE WEAR OF CONCRETE ROADS.*

By A. T. Goldbeck, Engineer of Tests, Office of Public Roads and Rural Engineering.

The ideal concrete road should wear uniformly and slowly. When due care is exercised in construction and the necessary precautions are taken in maintenance, uniformity of wear may to a large extent be controlled. But little is known about the rate of wear of concrete roads having various aggregates and carrying different kinds of traffic. General observation indicates that some roads with particular kinds of aggregates are wearing more slowly than others containing different coarse aggregates, even though the traffic conditions are nearly alike. We have, however, no definite idea of the amount of wear in these different roads. There must come a time in the life of every concrete road when, notwithstanding careful maintenance through crack protection and patching, its thickness will approach the minimum, making imperative the expenditure of a considerable amount of money for a new wearing surface to replace that gradually worn away by traffic. Every fractional part of an inch decrease in thickness therefore represents a very definite depreciation in the value of the pavement. Money can not be expended intelligently on various aggregates mixed with cement in different proportions for road construction without accurate knowledge of one of the most important factors governing the expenditure—namely, the probable rate of depreciation of the road as determined by actual wear.

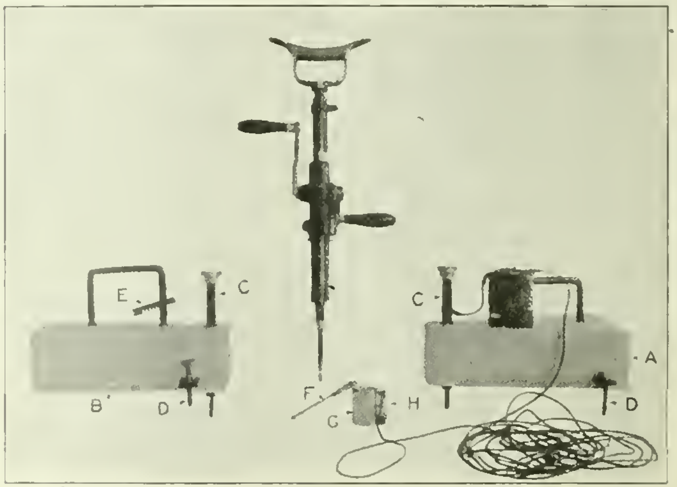


Fig. 1. Device for Measuring Wear of Concrete Pavements.

This consideration has led the Office of Public Roads and Rural Engineering to attempt to gain definite knowledge of the wear of concrete roads carrying various kinds of traffic, and a special instrument has been designed by the writer and built in this office for that purpose. Several methods of taking autographic records of the cross section of the road were considered, but were discarded in favor of the simpler and more portable form of instrument finally constructed.

Essentially, this instrument consists of a fine wire stretched tightly across the road at a constant height, together with an inside micrometer for measuring the distance from the road surface to the wire. Measurements taken 1 ft. apart across the road permit the plotting of its cross section, and if these measurements are repeated at long intervals the change of cross section or the decrease in the thickness of the road will be revealed.

The accompanying illustration shows the instrument in detail and its method of application on the road. Pieces A and B are made of cement mortar and have embedded in them steel rods, C, drilled with holes slightly inclined with the horizontal. A fine piano wire about 0.01 in. in diameter is passed through these holes and is stretched across the road from block A to block B. The tops of these rods are each provided with a disk-level bubble, so that when placed in position in the road the rods may be adjusted to a vertical position. Block A, which is heavier than Block B, is provided with two adjusting screws, D, for adjusting rod C to the vertical. Block B rests on two points only, one the lower end of rod C and the other the end of adjusting screw D. Constant tension is produced in the wire by the weight of block B, which is pivoted about the bottom of rod C and is adjusted to a horizontal position by means of rack E, provided at the end of the wire. As the weight of block B is constant, the tension in the wire, and consequently the amount of sag for like spans, must remain the same. A very definite and fixed datum is thus provided, which should remain constant from year to year and which is very easily established by merely placing the end blocks of the apparatus in their proper position on the road.

---

*Journal of Agricultural Research, Department of Agriculture, Washington, D. C. Vol. V, No. 20, Feb. 14, 1916.

The bottoms of rods C are spherical in shape; and when in use on concrete roads, they rest on the flat tops of bronze plugs cemented in the road surface. These plugs are ½ in. in diameter and are 1¾ in. long. They are set ¾ in. below the surface, and their tops are protected by means of a brass pipe plugged with a bituminous-sand mixture during the long intervals between readings.

In obtaining the wear measurements a chalk line is first snapped across the road between the bronze plugs, and the points at which it is purposed to take readings are marked on this line. At these points a steel block, G, 2 in. in diameter, is placed, in order to avoid measuring the small local inequalities in the road surface. In the top of this block a flat-bottomed cylindrical recess is made, and an ordinary inside micrometer is held in the recess, while its upper end is adjusted to contact with the steel wire stretched across the road. An electric buzzer, H, is mounted on the side of this block, and when contact is made between the micrometer and the wire and electric circuit is completed through the buzzer. With this instrument readings for wear may be taken to the nearest 0.001 in., although this degree of accuracy will not be necessary.

Holes in the road in which the bronze plugs are set are drilled by means of a special hand-operated drill press carrying a star drill.

The method of mounting the apparatus in the road and its manipulation are plainly shown. On the left is the heavier end block carrying the batteries, and on the right is the lighter block the weight of which supplies constant tension to the fine steel wire, part of which is seen in front of the operator. The cord extending on the road surface from the heavier block to the small steel block carrying the micrometer is one of the leads from the battery to the electric buzzer.

Placing the buzzer in this position near the operator obviously is advantageous, especially when the instrument is to be used amidst the distracting noises of traffic. The end blocks are set as near to the sides of the road as practicable, in order to permit measurements being taken across almost the entire width of the road. Should longitudinal cracks develop through the sections measured, the readings so taken will be rendered useless; and in order to eliminate this difficulty, sufficient plugs must be set to permit obtaining readings at uncracked sections.

Wear measurements of this kind taken of the actual road surface should prove of great future value if the traffic conditions and the physical characteristics of the concrete materials likewise are known, and should help to decide present moot questions regarding concrete roads and road materials. Not only may concrete surfaces be measured for wear in this manner, but the wear or vertical movement of other kinds of road surfaces may likewise be determined by the use of this instrument.

New Jersey Sewage Works Association.—Sixteen men, representing as many Jersey towns, met at Trenton recently and organized this Association. Mr. John R. Downes of Plainfield was elected president. There will be an annual meeting and two other meetings at different plants in the state.

THE FUNDAMENTAL PRINCIPLES OF THE ACTIVATED SLUDGE PROCESS OF SEWAGE TREATMENT.*

By T. Chalkley Hatton, Chief Engineer, Milwaukee Sewerage Commission.

The best definition of the "Activated Sludge" process which the writer has ever seen stated, is given by William R. Copeland, Chief Chemist for the Milwaukee Sewerage Commission, and is as follows:

> The sludge embodied in sewage, and consisting of suspended organic solids, including those of a colloidal nature, when agitated with air for a sufficient period, assume a flocculent appearance very similar to small pieces of sponge. Aerobic and facultative aerobic bacteria gather in these flocculi in immense numbers, from twelve to fourteen millions per C. C., some having been strained from the sewage and others developed by natural growth. Among the latter are species which possess the power to decompose organic matter, especially of an albuminoid or nitrogenous nature, setting the nitrogen free; and others, absorbing this nitrogen, convert it into nitrites and nitrates. These biological processes require time, air and favorable environments, such as suitable temperature, food supply and sufficient agitation to distribute them throughout all parts of the sewage.

Without serious study of this definition you will doubtless be led into the error, which many engineers have allowed themselves to be led into, that it is the old process of artificial air treatment in a more intensified form, and which has been tried out unsuccesfully by hosts of other experimenters.

It has been known for generations that air was one of the most important agents for the destruction of putrefactive organic matter; that if you could give the foulest sewage a given volume of air during an extended period all of the organic matters would be oxidized, and a stable effluent would result; that the air would break up the colloids in the sewage, from which it would be separated, and become attached to the suspended solids, until the added specific gravity, due to the combination, would cause them to settle to the bottom of a tank through which the sewage might be slowly passing.

This settled matter, called sludge, contained millions of the nitrifying and reducing bacteria, not only contributed by the sewage, but those resulting from the enormous multiplication due to the natural growth induced by the environments afforded them.

As they settled to the bottom of the tank they were aerobic in character, but, if the sludge was allowed to remain in the bottom of the tank, these aerobic bacteria disappeared and anaerobic bacteria took their places. Thus the real and vital purifying influence of the air was destroyed because the best nitrifying organisms, which grow and performed their work in the presence of the air, were lost.

The activated sludge process does two important things to overcome the old trouble; it preserves the aerobic bacteria by keeping the sludge, which is their natural food, in intimate contact with air at all times, and keeps them supplied with fresh food from the raw sewage, throughout the whole body of which they are in intimate contact. Heretofore the value of the sludge has not been realized in connection with aerobic bacteria, whereas in this process its presence is quite as important as the air, and to get the best results, it must be kept thoroughly mixed with every part of the sewage while the air is applied.

The writer's purpose in going into so much detail as to the definition of activated sludge is to try to make the engineer, who will be called upon to consider this process, realize the difference between this and other processes with which he has been familiar, and to acquaint him with its first principle. Since some of the results we have accomplished in Milwaukee have been published, we have received for criticism several plans of disposal plants designed to treat sewage by the activated sludge process, and, with one exception, all of these plans demonstrated that the designer did not have a clear conception of the principles upon which the process was based. How many other plans have been designed we do not know, but we are greatly concerned that the process will prove a failure in cases where engineers attempt to design a plant from the meager information already published.

---

*From a paper before the joint annual convention of the Indiana Sanitary and Water Supply Association and Indiana Engineering Society.

To those who want to go deeply into the technical phases of this new process of sewage disposal it is recommended that they write for and obtain a copy of the annual report of the Sewage Commission of the City of Milwaukee, which will be out of the printer's hands some time early in March, and which contains all the information upon the subject which we have learned to date.

ANALYSIS BASED ON MINNESOTA EXPERIENCE OF FORMS OF CONTRACTS FOR ROAD WORK.*

By R. W. Acton, Division Engineer, Minnesota State Highway Commission.

Five methods or forms of contracting have been used on road work in Minnesota as follows: (a) Lump sum; (b) Cost plus percentage; (c) Unit price; (d) Combination of lump sum and unit price; (e) Contracting for an outfit on per diem basis wherein the contractor guarantees a minimum yardage per day.

As to the merits of these various forms, the lump sum contract and cost plus percentage have proven the least satisfactory.

It is the writer's opinion that the straight lump sum contract is decidedly obsolete, inadequate and expensive on road work; obsolete in that it fulfilled its usefulness on the small job when supervision was not available; inadequate in that it provides for no contingencies, and expensive inasmuch as the contractor must base his bid upon the personality of the engineer or supervising board. Unit costs on strictly lump sum work have averaged much higher than costs for the same class of work under any other form of contract under the writer's observation.

The cost plus percentage form of contract is more satisfactory in theory than in actual practice. In theory it is perfectly reasonable to presume that work of an undeterminate nature, involving classification, doubtful foundation work, work under water and other extreme conditions, should be handled on a cost plus percentage. The system has thus far apparently failed in that too often the county is paying for the experience of the contractor, in which situation there is no advantage over the rental of equipment and performing the work by day labor. However, where the percentage cost actually goes towards the purchase of experience, this system should be very acceptable.

The more successful form of contract has been the "Unit Price," "Combination of Lump Sum and Unit Price" and the contracted outfit on per diem basis with a guaranteed minimum yardage. This latter method has been found successful locally, and is applicable in conjunction with day-labor work only. The combination of the lump sum and unit price is a compromise which has been read into the statute governing certain public work under which lump sum contracts are prescribed. As applied to road work the contractor is required to bid upon unit prices for each and every item or classification of work. The unit prices determine the amount of the contract and are also the basis for settlement for extra work or deductions.

By carrying a contingency fund it is possible to secure very satisfactory results with this form of contract as it acts as a curb upon the engineer who might be extravagant, has a tendency to balance the contractor's bid and gives the county a reasonably close estimate of the final cost of project. This is the most satisfactory form of contract that has come to the writer's observation on bond issue work when a form of the lump sum contract must be held to comply with the statute.

The unit price from an engineer's and contractor's point of view is the ideal form of contract and without question it is the fairest method of contracting and is conducive to the securing of the lowest possible unit bid. Contractors feel more safe under this form of contract, in that omissions of sufficient quantities in original estimate, revisions in compliance with engineer's instructions or desires of supervising boards can be made without a question as to method of final payment. The principal and somewhat justifiable objection to the unit cost system lies with the supervising boards who feel that there are not sufficient restrictions upon the engineer.

---

*Extract from a paper read at the annual meeting of the Minnesota Engineers' and Surveyors' Society.

STEVENS INSTITUTE OF TECHNOLOGY COMPLETES PURCHASE OF NEW GROUNDS FOR FUTURE EXTENSIONS.

Stevens Institute of Technology recently purchased a block of ground comprising about two acres, lying directly east of the main building. This purchase, together with the purchase of seven acres last fall from the private grounds of the Stevens estate, gives to the Institute all of the land north of Fifth St. to the Castle and permits of future building to the best advantage, both as to the general appearance and convenience. It marks the consummation of plans laid down by President Alexander C. Humphreys some years ago for the acquisition of such available land in the immediate vicinity of the college as might be necessary for future development. The block of land just obtained contains three private dwellings which for the present, at least, are not to be disturbed. The college now possesses a total of about 23 acres lying on rising ground in the city of Hoboken, N. J., with the Stevens Castle at the crest. It has a frontage of 1,600 ft. on the bluff overlooking the Hudson River, New York City and the Narrows. A gymnasium is under construction immediately adjoining the athletic field on the seven-acre parcel of land mentioned above. During the past two years the Institute has had a rapid growth, the number of entering students having been the largest in the history of the college and double that of the years immediately preceding. If the entering classes continue to be as large the next two years, it will be necessary to make early provision for new buildings on the new ground just purchased.

FOR FAIRNESS AND DEFINITENESS IN SPECIFICATION WRITING.*

By N. T. Veatch, Jr., of Black & Veatch, Consulting Engineers, Kansas City, Mo.

Quite often there is a discrepancy between the specifications and the detailed plans, and sometimes neither one is clear. Quite often the engineer inserts in his specifications the phrase: "Meet the approval of the engineer" or "It shall be left to the discretion of the engineer." But isn't such a practice unfair to begin with, and also dangerous from the engineer's standpoint? It is unfair to ask the contractor to bid on something which the engineer may select later, and it leaves an opening for criticism of the engineer even though all of his decisions are made in all honesty and to the best of his ability. The specifications should describe in such detail the work to be constructed, that from them and the plans, the contractor should know exactly upon what he is bidding. This has a two-fold benefit, for the engineer need have no hesitancy in holding the contractor to the exact terms of the contract and his bid.

Trouble is more apt to come in specifying the material used and the manner of connecting up the different larger items of the contract, than in the specifications for the items themselves, as the latter are given special attention in nearly every case. An example of this would be the case if an owner purchased a motor-driven pump erected and tested, the contractor to do the wiring from the switchboard to the pump. Another contract brings the wiring to the outside of the building but nothing is said about connecting from the switchboard to the wiring outside. It was unquestionably the intention of the engineer that the contractor furnishing the pump should do all wiring inside the pump-house but the specification did not state so clearly. This work had to be carried on as extra. In one way the owner was out nothing as he would have had a higher bid from the contractor had this piece of wiring been called for, but on the other hand he did not get the advantage of competitive bidding as would have been the case if the specifications had covered this particular piece of work. Such mistakes as these are not to be compared with mistakes of engineering judgment, but nevertheless they cause annoyance and embarrassment and can be avoided by using care.

---

*From paper before Kansas Engineering Society.

There has been a tendency on the part of a good many engineers to draw their specifications in such a way as to make the contractor responsible not only for the faithful performance of the contract but for the results to be obtained from the engineer's design. As a matter of fairness the engineer should not attempt to get out of all responsibility. An example of just such a thing happened recently in Kansas. An engineer drew plans and specifications covering an elaborate underground collecting system for a water supply, and specified that the contractor should guarantee a certain number of gallons of water per day from the system. The system was put in in exact accordance with plans and specifications, but they were able to get only a little more than one-half the amount which the contractor had agreed to supply. Now then, who was responsible for this falling down in guarantee? Was it the contractor or the engineer? There can be but one answer. It is fair and right to draw rigid specifications covering features pertinent to the work to be done, but it is wrong to specify the manner in which any piece of work is to be done, and also make the contractor responsible for results. The statement may be made that the contractor had a chance to investigate conditions and satisfy himself before entering into the contract. Suppose he did, was not the engineer hired, on account of his special knowledge, to design the system, and didn't he take days and maybe weeks and months to investigate the conditions and draw his plans? How then can a contractor be expected to pass on the feasibility of the plan, in one or two days spent in going over the ground? It is not right to expect it, and if the engineer is not sure enough of his plan for the improvements to take the responsibility for results provided his plans are followed exactly, his services are really of very little value to the owner.

There is one place where it is the universal custom to specify the guarantees which the contractor must make. This is in buying mechanical, water-filtering material. The only excuse for this is probably the fact that filtration has passed the experimental stage, and possible results from the several different plans of filtering water are well established. Quite frequently engineers do not detail the plans for filtering equipment, leaving it entirely to the contractor. This makes it impossible to have all bidders bid on the same thing. It also throws the burden of design onto the contractor, and the engineer shirks a duty he should perform. If the engineer is unable to design the improvement himself he should not have the work. If plans are drawn showing the arrangement of basins and all equipment, it is questionable whether or not it is fair to stipulate the guarantees, although this instance is somewhat different from that of the contractor guaranteeing a certain amount of water from a designed collecting system, as the former does not have the uncertain features of the latter.

In buying any equipment, such as filter equipment, pumps, engines, and other machinery, it is impossible, and also unwise to expect all manufacturers to conform to the exact wording of the specifications, as regards minor details, as each one has standards which he follows, and unless he build the pump special, each will bid on standard equipment. This is what the engineer should want, as it would be unwise and entirely unnecessary to incur the expense of building the equipment with special paterns, etc. The specifications should state clearly the exact conditions under which the equipment machinery is to work, and the results expected, and the contractor should be asked to fill in his own guarantees. To explain the above, consider the case of the purchase of a pump. The engineer should determine the type of pump to be used. He should then give clearly and minutely the exact conditions under which the pump is to operate, which information should include the amount of water pumped, the head pumped against, etc. In this case it would be useless to go into such detail as to describe all the different parts of the pump. In the first place unless required to do otherwise, the bidders will all bid on their standard equipment, using the size which meets the conditions laid down in regard to operation; and also there are few engineers in practice, who are fitted to design in detail different pieces of machinery as well as the experts in the employ of the manufacturers. The engineer is better fitted, providing he has had the proper experience, to determine the type of installation, and other engineering features, than the average salesman, especially because he generally does, or at least should, spend more time in studying the situation. There are a large number of good engineers in the employ of manufacturers as salesmen, and cities quite frequently depend on their judgment in determining the equipment to be used. There are very few if any salesmen who will not allow themselves to govern their recommendations by the equipment they are most anxious to sell. The question of type of improvements and manner of making them should invariably be left to some good, unprejudiced engineer. The decisions will be unbiased, and plans and specifications will allow of competition, which is not the case when drawn by some manufacturer or his agent. A large amount of money could be saved if every proposition were handled in this way.

Specifications are drawn primarily to protect the party paying for the work, and it is not the intention of this paper to advocate anything that would not give this protection. It is desired, however, to point out the ways in which poorly prepared specifications, those which put impossible guarantees into the contracts, and those having unreasonable stipulations, act as a detriment in protecting the owner. Specifications should be rigid, and drawn so that there can be no question in regard to what the contractor is to do. If this is done the contractor can have no excuse for objecting to live up to specifications, regardless of his bid, as he was given an opportunity to know exact conditions.

COST OF TRIMMING GRASS ALONG WALKS AND CURBS IN BOULEVARDS.

Contributed by H. R. Ferriss, 203 Times Block, Victoria, B. C.

The cost of trimming grass along the edges of walks and curbs in boulevards was observed as follows on a total length of 66,000 lin. ft.:

Labor, 220 hrs., $44; $0.67 per 1,000 lin. ft.

The "trimming" costs given above include the work around many lamp standards, hydrants, etc., which costs could not be separated. The "trimming" was done with home-made shears, having long handles (so that the workman would not have to stoop), blades about 12 in. long, and mounted on ball-bearing wheels similar to those on roller skates.

The methods of several different park boards were tried, before adopting the foregoing method, and various tools, including edging mowers, other designs of shears, etc., but, after carefully trying out the various methods, it was decided that the most economical result was obtained with the shears as described above, providing the man was skillful in their use. Some of the methods tried gave lower first costs, but the results were poor and necessitated trimming at more frequent intervals. One park official usually did this work by sending one man ahead with a stiff broom, who swept the grass back from the edge of the walk or curb, while another man followed with a lawn mower. This method was tried by us, and is certainly faster and gave a lower first cost, but required to be done oftener, and the resulting appearance was not as neat.

This cost of trimming is usually regarded as an insignificant item, and is generally overlooked. However, in finely kept parks and boulevards, with long stretches of curbs and walks, it must be done at least once in two weeks (or even oftener), and during the course of a summer may become a considerable item. We find that a great difference in the cost comes from practice, and if a good man can be kept steadily at this work, the resulting cost will be much lower than if green men are used from time to time.

THE FALL RIVER CONCRETE CONDUITS—SPECIAL REFERENCE TO A THREE-LEVEL CONDUIT OF UNIQUE DESIGN.*

By Frederic H. Fay, of the Firm of Fay, Spofford and Thorndike, Consulting Engineers, Boston, Mass.

This article is the very brief statement of a complicated municipal problem in which are involved many questions of sanitation, of stream control, of mill engineering, and of city planning, and to which a concrete conduit of peculiar design furnishes the key.

Location.—Fall River, Mass., the largest cotton manufacturing center in the United States, is a city of about 125,000 population, located on the seacoast on a tributary of Narragansett Bay, some 50 miles south of Boston. Its location is most favorable for manufacturing; in addition to ample rail facilities, there is a good tidal harbor on the west of the city, while to the east, and within two miles of City Hall, lie the Watuppa Ponds, which are at an elevation of 130 ft. above sea level and furnish water for both domestic and manufacturing purposes. The North and South Watuppa Ponds, originally one large lake, 8 miles long and 5¼ square miles in area, constitute the largest body of fresh water in Massachusetts. The lake has been divided into two parts by the building of a causeway or dam at the Narrows. These ponds drain a watershed 27½ square miles in area. The total storage capacity of the two Watuppa Ponds is 15,000,000,000 gals., while about four billion gallons in addition are stored in three tributary ponds lying to the south. Only a fraction of this total storage is now available, however, since it is not possible to draw these ponds down to any considerable depth. The North Pond is chiefly used for the domestic water supply of the city. The water of the South Pond and of the three tributary ponds, with a certain amount of North Pond water which is drawn into the South Pond, is used for mill purposes. About one-quarter of the total yield of the watershed is used for the domestic supply and three-quarters for industrial purposes.

Quequechan River.—The outlet of the Watuppa Ponds is the Quequechan River (the Indian name, "Falling Water"), which flows from the South Pond through the heart of the city. For the first two miles, from the pond to a point near City Hall, its course is almost level, thence in the last half mile it drops 130 ft. through a succession of falls and empties into the harbor known as Mount Hope Bay. The name of the city was derived from this stream, and from earliest times the water power of the stream has been utilized by mills along the lower half mile of its course.

For the first two miles of its course the Quequechan was originally narrow, winding through meadows. Ninety years ago the mills at the various falls, desiring to obtain greater storage of water for power purposes, combined under a charter from the legislature of Massachusetts and built a dam at the uppermost fall, which raised the level of the water in the stream and in the Watuppa Ponds to a height about 5 ft. above natural high water mark. As a result some 200 acres or more of the flat meadow land bordering the upper two miles of the stream were overflowed to a shallow depth.

With the introduction of the steam engine, mills were built around this upper river basin to use the water for boiler feed and condenser purposes. The city has grown around these mills until today the 200 acres of shallow flowed flats are in the very heart of the community.

Of a total of 4,100,000 spindles in all the cotton mills of Fall River, nearly two-thirds, or 2,638,000 spindles, are found in the mills along the 2½ mile stretch of the Quequechan River. Of these latter spindles about 2,000,000 are in the 27 mills surrounding the upper basin. Today water power is a negligible factor, the river water being used almost wholly for condenser and other industrial purposes.

The sewers of the city have not kept pace with the growth of the population of this district, and for years the sewage from most of these mills and from a considerable district bordering the basin has been discharged into the Quequechan. In addition to sewage, the stream is polluted by the discharge of bleachery, dye and other mill wastes.

During wet months when water is abundant and the ponds and Quequechan Basin are filled nearly to high water level, conditions are not particularly objectionable. During the dry months, which usually occur in the summer and fall, however, the water of the ponds and basin is usually drawn down 3 to 4 ft., exposing flats covered with an obnoxious sludge consisting of sewage, silt and mill wastes. Also, at such times the mills are seriously hampered by lack of sufficient water for condenser purposes. Those bordering the upper basin require some 30,000,000 gals. per day, while the flow of the stream is often reduced to 5,000,000 gals.; the result is that the water is drawn from the stream and returned to it again after being passed through the condensers of mill after mill, until frequently the entire flow of the river becomes heated to 100° to even 120° and has little value for the cooling of condensers.

So far there has been utter lack of co-operation among the mills and no policy of conservation in the use of this water. The result is that there are low water periods nearly every year when the mills suffer for lack of water and conditions in this thickly settled community become highly objectionable from the standpoint of health.

The Remedy.—For many years the need of improving conditions along the Quequechan River has been recognized by the city of Fall River, and several tentative plans have been suggested. Recently, however, the whole situation has been most thoroughly studied by a local municipal commission appointed under authority of a state legislative act and a remedy has been proposed, the acceptance of which is now under consideration by the city authorities.

The proposed scheme of improvement will completely abate the present nuisance and, by the development of 100 per cent increase of storage capacity in the South Pond will so regulate and utilize the flow that the mills will have an ample supply of water at all times.

In general the proposed improvement provides for the following:

1. The construction of a large reinforced concrete main conduit, nearly two miles in length, which, with its branches, will provide: (a) An adequate supply of clean, cold water to all mills along the stream; (b) for the return of the hot water discharged from the condensers of the mills above the Watuppa Dam to the South Pond, where after purification and cooling, it will become available for use again; (c) for the discharge into an outfall sewer of the surface water which now flows into the Quequechan River; and (d) an adequate channel, by which in times of flood, the waters of the Watuppa Ponds can be drawn off and discharged into the harbor before they rise to a level that would cause damage.

2. The construction of a system of reinforced-concrete drains to collect and to bring to the main conduit the surface drainage of the Quequechan valley watershed.

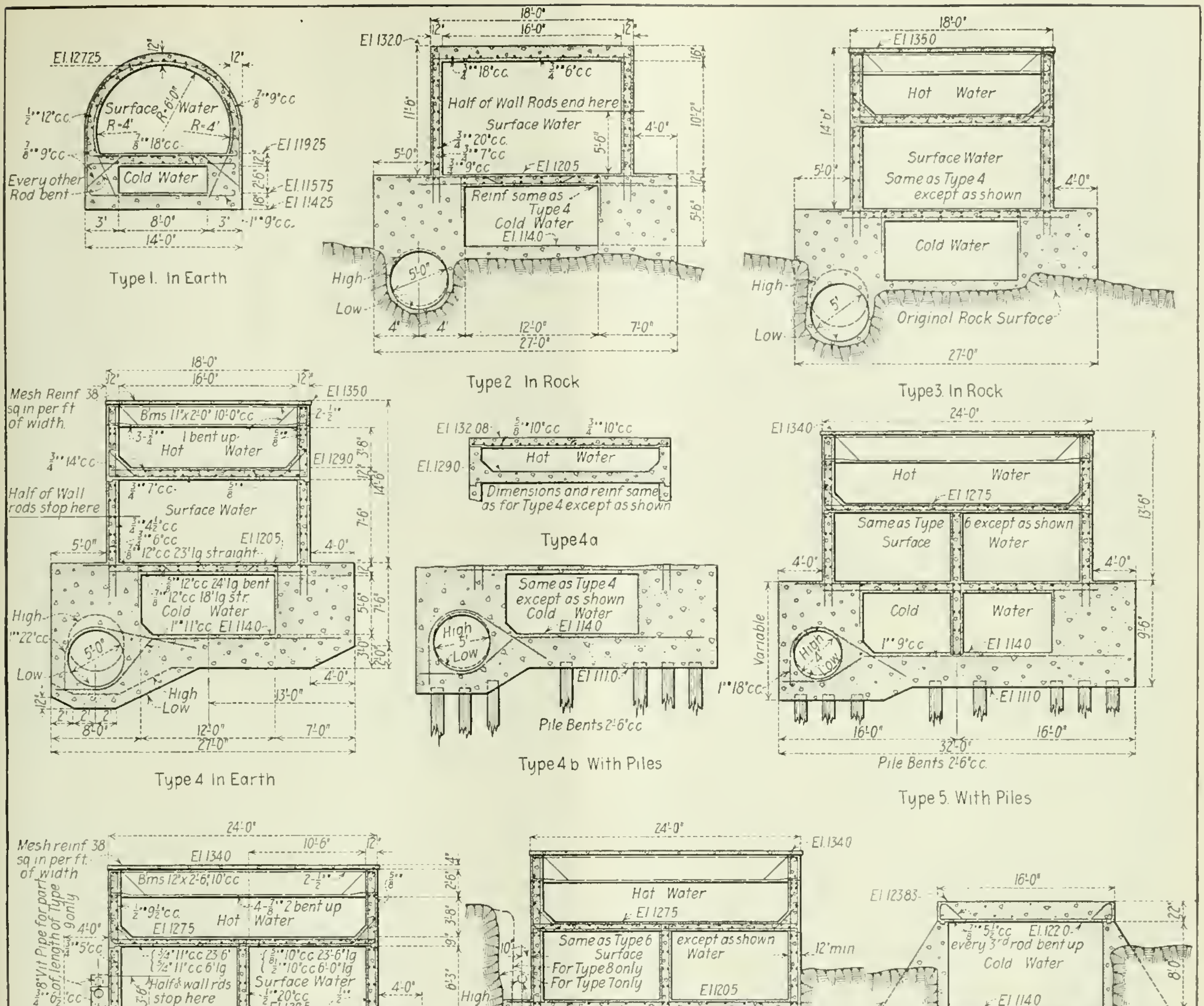
3. The construction of a system of reinforced-concrete sewers to care for the sewage of the present unsewered district along the river.

4. The construction of a large outfall sewer, one mile in length, by which both the sewage and storm drainage thus collected will be taken to the waterfront of the harbor.

5. The filling of the entire area of the Quequechan River flats some 200 acres in extent, thereby not only abolishing the nuisance which is always present at low water

---

*Paper before American Concrete Institute.



TYPICAL CROSS-SECTIONS OF MAIN THREE-LEVEL REINFORCED CONCRETE CONDUIT PROJECTED AT FALL RIVER, MASS.
(This conduit is the key to the solution of a highly complicated municipal problem involving questions of sanitation, stream control, mill engineering and city planning.)

when the sewage-covered flats are exposed but also making available for industrial or other uses a large tract of land in the heart of the city, the value of which will offset in part the cost of the proposed improvement.

The Three-Level Reinforced-Concrete Conduit.—Investigation of a number of possible schemes showed that a satisfactory solution of the problem could be reached only by confining the river within an artificial channel and filling the entire area of the shallow-flowed flats. A concrete conduit was finally selected as the proper type of river channel. Furthermore, in order to develop greater storage capacity in the South Watuppa Pond it was found essential to place this new river channel, the cold water conduit as it is called, at a level considerably below the present river bed.

As the mills along this two-mile stretch of conduit require water for condenser purposes to an amount considerably greater than the normal average flow of the stream, a separate channel was planned by which the hot water discharged from these mill condensers could be taken back to the South Watuppa Pond for use again. It was found that if this hot water conduit is at sufficiently high elevation, the condenser water will return to the pond by gravity. The hot water conduit was placed directly over the cold water conduit, thereby avoiding the expense of separate foundations and reducing to a minimum the area of land required for conduit purposes.

The intervening space between the hot water and the cold water conduits has been advantageously utilized as a main surface water conduit to carry off the surface drainage from the Quequechan valley watershed. Embedded in the walls of the cold water conduit is a main sanitary sewer, which received the sewage from the system of sewers mentioned above. The main conduit, with its multiple compartments, is shown herewith by several typical cross sections.

In the three-level type of conduit here proposed, provision has thus been made for carrying down stream, in separate channels, the natural flow of the river, the storm water drainage and the sewage; while the hot water from mill condensers is carried up stream to the South Watuppa Pond. It has been found feasible to build the cold water and surface channels level from end to end, while the hot water channel has a slight slope toward the South Pond. The incorporation of these several channels into a single concrete conduit of three-level type has resulted in a most economical and unique design.

Detailed Design of the Three-Level Conduit.—So far as is consistent with stability, the main three-level conduit has been designed as a reinforced-concrete structure. For a considerable portion of its length, however, this conduit is to be built in gravel and other porous material, in which the level of ground water will stand nearly at the top of the conduit. In view of the fact that the several conduit channels may all be empty at the same time, the lower section of the structure was designed of massive concrete to give it sufficient weight against possible flotation. Further, it will be possible, if found desirable, to deposit this mass concrete in water within the walls of a temporary cofferdam, thus sealing the bottom and rendering the unwatering of the cofferdam by pumping a simple and easy matter. Under the program of construction proposed, however, it is planned to dike off that portion of the river in which the conduit is to be built, and to carry out practically all of the construction in the dry. Above the mass concrete of the cold water channel, the side walls and the floor, both of the surface water and of the hot water channels, are of thin reinforced-concrete construction. To avoid objections to an open channel, the hot water channel is covered by thin reinforced-concrete roof slabs, supported upon reinforced-concrete cross-beams, the roof slabs being removable so that access to the hot water conduit from the surface may be had at any point.

Expansion.—The usual provisions for expansion are to be made, care being taken to secure water-tight joints. The hot water channel is exposed at the surface of the ground, and because of this fact and also because it carries an intermittent flow of hot water is subjected to greater variations of temperature than other portions of the three-level conduit; consequently provision has been made for the expansion and contraction of the hot water channel independently of the remainder of the structure. In effect, the hot water channel with its cross floor is simply supported on the vertical walls of the surface water channel, horizontal expansion joints being provided at the top of these walls.

The provision for longitudinal expansion of the surface water portion of the three-level conduit consists of vertical expansion joints in its vertical walls at intervals of approximately 60 ft.

No provision for expansion has been made in the mass concrete section of the cold water channel, and this is buried to a depth of about 9 ft. below the surface of the ground, the water in it is drawn from a level quite below the surface of the lake, and no considerable variation of temperature is expected in this mass concrete.

Sewer Construction in the Main Conduit.—The sanitary sewer located in the side wall of the cold water section of the main conduit is to be built as a reinforced-concrete pipe sewer, in advance of the construction of the conduit itself, in order to provide for the drainage of the area of the conduit trench which is to be unwatered for the construction of the main conduit. As the construction of the conduit proceeds, this pipe sewer is embedded within it.

Cold Water Intake.—The water for the cold water channel of the main conduit is admitted at the end of the intake in the South Watuppa Pond, about 900 ft. from shore. This part of the intake is built as a reinforced-concrete box, without bottom, 18 ft. wide and 9 ft. high in inside dimensions. The box has removable covers of reinforced-concrete. The water is admitted through openings in the upper part of the sides and end of this box, the bottoms of the openings being from 4 to 5 ft. above the level of the pond bed and the tops of the openings, which are 4 ft. in height, being about 8½ ft. below full pond level. By the construction proposed it will be possible to draw the South Pond down 8 or 9 ft. and still maintain a full flow in the cold water conduit; further, the water is taken at a level which will avoid the draft of any roily water from the bottom or of any warmed water from the surface.

From the box at the end of the intake to the shore, the intake structure consists of a series of reinforced-concrete sections of semi-circular shape. A channel is to be dredged in the bed of the South Pond for the whole length of the intake, and covered with a thin layer of broken stone upon which the concrete intake structure will rest. The several sections of intake are to be cast on shore and taken out and lowered into position by means of scows.

Gate Houses.—Two gate houses of somewhat complicated design are provided, one near each end of the main conduit, to regulate the flow of water to and from the several channels.

Mill Connections.—Manholes are provided at the sides of the triple conduit through which water is supplied to the mill intakes. While the normal mill supply is to be taken from the cold water conduit, two sets of gates are provided at each manhole, so that in case it is desired to empty the cold water conduit at any time, water for the mills may be temporarily drawn instead from the surface water conduit. The intake leading from the manhole to the mill consists of a reinforced-concrete pipe, usually 36 ins. in diameter, placed well under ground, at a level such that the pipe will flow full when the South Watuppa Pond is drawn down to its minimum working level.

To carry the hot water discharge from the mill condensers back to the hot water channel of the three-level conduit, wooden flumes have been used. These flumes must in any case be kept at a high elevation, practically at the proposed surface of the ground in order to afford gravity flow, and in most cases the ground will be filling placed upon the present flats. These cheap and flexible wooden flumes will serve admirably until such time as this filling has settled to a permanent level and permanent return channels can be built.

Branch Conduits.—Many of the mills are remote from the proposed main conduit and to supply them branch conduits have been designed. These are generally of the three-level type, and in certain cases include a sewer. In the Cornell and Stevens branches, however, it is not necessary to provide for storm water or sewage, and these two branches are of two-level type, carrying cold water and hot water only.

Grit Chambers.—To clarify partially the storm water collected by the surface water drains, grit chambers are provided wherever these drains connect with the main or branch conduits. In each case the grit chamber is a reinforced-concrete structure so designed that the maximum storm flow will pass through the chamber at the rate of 1 ft. per second, and the chamber is usually 60 ft. in length. Suitable baffles are provided and it is expected that much of the solid matter washed from the streets will be deposited in the chamber during the minute of time that the storm water is passing through it.

Outfall Sewer.—The outfall sewer previously mentioned is designed to receive both the storm water and sewage flow at the lower end of the triple conduit and take it to tide water in the harbor. The sewer is to be a mile in length, about half of tunnel construction in rock and the remainder of reinforced-concrete construction in open trench. Provision is made to take the sewage flow into deep water at some distance from shore, so that it may be carried off by tidal currents without offense.

From what has been said, it is apparent that this system will perform the functions demanded of it.

1. It will draw from the pond at low level and deliver to the mills a constant and ample supply of clean, cold water.

2. It will receive from the mills above the Watuppa Dam the water heated by their condensers and will convey it back into the pond at high level, where, after purification and cooling, it will become available for use again.

3. It will receive the surface drainage from the slopes of the valley and discharge it through the outfall sewer into tide water.

4. It will carry away at times of freshet any surplus water accumulating in the ponds and thus obviate, for the future, any danger of floods.

5. It will receive all the sewage which it will ever be desirable to carry along this route, and will discharge it into tide water through the outfall sewer.

6. By substituting for the river the covered channels used for the above purposes, it will enable the existing flats to be filled, the nuisance to be abolished and this large amount of valuable land to be added to the business and manufacturing district of the city.

The channels required each must receive large and important branch channels. Were any two main channels placed side by side, one of them could not be reached by branches on one side, except by passing under, over or through the other channel, a matter involving difficulties in construction and still greater difficulties in maintenance and operation. Consequently, the main channels are placed one over the other. The result is almost of necessity the cellular type of construction shown. No material heretofore known has anything like the advantages for such construction as has concrete. The massive concrete can be placed under water in the foundation, as can no other type of water-tight masonry. The reinforced-concrete walls and floors, acting not only as slabs but as vertical and horizontal beams or girders, provide a rigid structure which can be erected on the not always firm foundations, and can be surrounded by freshly deposited filling and subjected to the heavy earth pressures developed by it with confidence that settlement or deformation will be slight, since the structure will of itself tend to span across the soft or yielding material and deliver the pressures wherever it can best find supporting resistance. Concrete, both from the materials composing it and the conditions under which it must be placed, is exceptionally adapted for such a structure and such a locality. Reinforced concrete is the only material, whether masonry or metal, yet known which could perform these functions so economically and at the same time permanently resist the deteriorating effects of the earth and water in contact with it.

METHODS OF MAINTENANCE OF NEW HAMPSHIRE GRAVEL ROADS.*

By Frederick E. Everett, Commissioner, Highway Department, Concord, N. H.

It is a common rule that the finest roads are the result of good construction and a system of maintenance whereby every defect is corrected before it has time to cause serious damage. This rule is chiefly applicable to a gravel road for the very obvious reason that if we are to build gravel roads and expect them to give their users the same satisfaction that the more expensive types would give, we must maintain as near a true section as is possible free from ruts and holes.

There are two general forms of maintenance, which may be called continuous maintenance and periodical repairs. The type of road to which they are applied should regulate their selection. It would certainly be a waste of money to employ constant maintenance upon a high class pavement which we have every reason to expect will wear uniformally until such time as to need resurfacing. On the other hand it would be poor policy to let a gravel road go until it needed resurfacing. It is important that every rut and hole should be filled as soon as they appear for they will hold water which will soften the gravel bed and cause the road to wear rapidly.

What is the best method to adopt to accomplish this continuous maintenance. There can be only one answer to this so far as the gravel road is concerned, namely, the patrol system. A patrolman equipped with a one-horse ditch shovel, rake and drag, etc., given a mile of road per diem, will find plenty to do. A gravel road to insure the maintenance of its cross section should be dragged after every rain. Under the periodic system we could not do this as it was impossible to provide so that your maintenance gang would be at the proper places at the proper time.

A gravel road can be too wet or too dry to drag. There is a certain time after a rain when the road is in the best possible condition to work and obtain results. The patrolman constantly on the road knows just when this time arrives. He discovers the weak places. He sees the small hole when it starts and before it has developed into a large one or a series of small ones. He patches the roads in the early stages of disintegration without serious trouble or excessive cost.

As an illustration of the favor in which we hold the patrolman's services, I will cite the increase that has been made in this branch of our organization. In the year 1911 there were two men employed as patrolmen on one of our trunk lines for about two months. This was our first attempt with the patrol system. We have already appointed for the year 1916, 225 patrolmen. These men will be employed from April first, or sooner if the weather conditions permit, until December first. Their average pay will be $3.25 per day. Now arises the question, how much money can be justifiably expended in the maintenance of a gravel road? An article published in the "Engineering News" of Dec. 9, 1915, answers this question to perfection.

> Assuming the cost of a modern country road pavement of the so-called "permanent" type at $15,000 a mile (conservative) and supposing this to be paid for by twenty-year bonds at 4½ per cent, the annual charges for interest on and redemption of the bonds amount to about $1,150 per annum. It is safe to assume that even the most "permanent" type of country-road pavement will require repairs and maintenance of at least $50 per mile per year, or in round figures we have a minimum of $1,200 per mile per year as the cost of the improved road.
>
> Assuming that a good gravel road may be built for $4,000 per mile (which we have shown is more than the average cost of New Hampshire roads), the annual charges for interest on and redemption of bonds (if the roads are built by bond issues) at the end of twenty years would amount to about $310. Therefore, it is theoretically economical to spend nearly $900 per mile per year for the maintenance of gravel roads, if for that sum the roads can be maintained in a condition equal to a pavement in the $15,000-a-mile class.

Our claim is, that in New Hampshire, we are able to maintain this condition on four-fifths of our roads. This four-fifths carries an average traffic of about 300 to 600 vehicles, mostly motors, per day during the vacation season.

---

*Extract from a paper read at the Pittsburgh convention of the American Road Builders' Association.

From the comparison just cited, we find that we can economically spend $900 per mile per year for maintenance. Under the patrol system we do not find this expenditure necessary. Taking 40 towns in New Hampshire whose state roads have been built of gravel and maintained by the patrol system, we find that in the year 1915 our average cost of maintenance per mile was $240. This cost includes in some cases the surface application of a light asphalt or non-asphaltic oil. I will leave it to your judgment if this type of road is not the most economical for moderate traffic.

RELATION OF RIVER STAGE TO WATER LEVEL IN NEARBY WELLS.*

By C. A. Haskins, Engineer, and C. C. Young, Director Water and Sewage Laboratory, Kansas State Board of Health, Lawrence, Kans.

In securing water from wells in river valleys, the common belief among laymen is that a certain amount of the water is collected normally from the sand and gravel deposits that has not yet reached the river, and also that large quantities of water pass from the river through the sand and gravel to the wells. Such seems to be the general idea of the source of supply at Lawrence, Topeka, Manhattan, Salina and many other places in Kansas. As a matter of fact, however, it is very seldom true that water is secured in the latter manner. This belief is caused probably from the fact that usually during times of flood wells close to streams seem to contain more water and yield it more readily than in times of dry weather, and the conclusion that this excess of water comes from the stream is but natural. Most of the streams, however, during times of flood carry large quantities of finely divided sediment. When water carrying sediment attempts to pass through a layer of porous material the flow is broken up and the rate of travel is lowered. Since the carrying of sediment is dependent upon the rate of flow and the size and specific gravity of the sediment being carried, it will readily be seen that this finely divided material will be deposited, or possibly be strained out of the water. In a very short time the porous material will be completely filled up—that is, clogged by it, so that very little, if any, water may pass through it. Since the ground water flowing along the banks of streams tends to flow into the river and appear in seepage along the river banks, a slight rise of the water in the river would furnish a pressure to hold back this ground water from such seepage; consequently the rise of the ground water would be expected in any well drilled on the river bank at times of flood.

An interesting proof of this fact has been developed at Lawrence. The city supply is secured from a layer of sand and gravel along the west bank of the Kansas (or Kaw) river. From time to time during the years 1909, 1910 and 1911, sufficient analyses of the Kaw river water and the Lawrence city supply had been made, so that the chlorine content of the ground water was known to be very nearly constant, while that of the river water varied between wide limits. On account of the fact that a sufficient supply of water from the ground could not be secured, due to inefficient methods instituted by the water company, it had been the custom to reinforce the supply with water directly from the river. Therefore, if it were known when the river water was being used, changes in the chlorine content of the two waters could be accounted for. A study of the results of the analyses for chlorine in the two waters, and of the periods during which the river water was added to the city supply, will convince one that the river water only reached the supply through a pipe connecting it directly, and not through the wells.

Further proofs of this general statement may be found in the water supplies of two or three of our cities in the southeastern part of the state. They attempted a few years ago to develop a supply of river water, purifying it by a filter consisting of an underground tunnel connecting the suction well directly with the river water. These tunnels were filled with gravel, sand, "chats" and other porous material, with the hope that the river water filtering through would be sufficiently clarified to be suitable for domestic use. The experiences of all of these cities were that shortly after the river water was turned into the so-called filters, the filters became so clogged with sediment that it was impossible to get a sufficient supply through them, and it was necessary to clean them out with dynamite in order to get water. This same condition may be shown in the operation of water filters. In filtering the turbid water of our western streams it is the practice to pass water through a bed of sand and gravel 35 or 40 in. thick, collecting it underneath through a system of strainers. The water is passed through the sand to a clear well at the rate of about 2 gal. per minute per square foot of filtering surface. The silt and mud thus filtered out of the water collects on the top of the filter bed, and it is necessary each day, in order to keep water going through the filters, to pump a reverse current of water back from the clear well through the strainer system and up through the sand, in order to wash out the accumulated mud of the day's run.

Certain conditions will permit water to travel from a stream into a well. For instance, if there is a direct connection of a fissure through limestone, the water in the river will affect the level of the water in the well. Also, in some streams in western Kansas the character of the soil around them is so very coarse, consisting principally of sand and gravel, that the water in the stream will entirely disappear, dropping down into the underflow. In some of these cases, where wells are close to the stream, a direct connection might occur. As a general rule, however, this is not probable.

MINNESOTA DRAINAGE LAW AND ENGINEERS' COMPENSATION.*

By Roy H. Allison, County Surveyor, Blue Earth County, Minnesota.

A matter of no small importance is the compensation to the engineer. Is there any reason why drainage propositions could not be worked on a percentage basis; this percentage to be fixed in proportion to the size of the job as is customary in public improvement work such as bridges, sewers, disposal plants, etc.? We are allowed $7 to $7.50 per day and actual expenses for our work. Under ordinary conditions a job of $75,000 to $100,000 will cost less than 1 per cent at the above wages for plans and estimate. I believe that any engineer would be rightfully entitled to at least 2 per cent for such plans and estimates and would receive that amount on any other public work. If worked on a percentage basis there is an opportunity for an engineer to make what he is entitled to in handling several jobs at the same time. As I understand the present laws it is unlawful for an engineer to make any profit on any of the assistants employed by him on any public ditch; notwithstanding the fact that the engineer in charge is bonded for all the work done by the assistants, he can legally collect only $7 or $7.50 per day for the time which he actually puts in himself. This is true whether he has just work enough to keep himself busy or whether he has work enough to keep five or six assistants employed. Why not put drainage work on a percentage basis or allow a reasonable profit on assistants employed? Along the same line the present law allows the payment of from $5 to $10 per day for an engineer, $2.50 per day for a rodman and $2 per day for chainman. Why not allow the employment of a levelman at a reasonable price per day. It is often necessary to have a transit party and a level party employed at the same time. Now a man may be very proficient in level work and yet hardly qualify as assistant engineer, yet it is necessary to have such a man sworn in as assistant engineer if he is to receive over $2.50 per day. Of course, should the percentage system be adopted this difficulty would be disposed of.

---

*From Engineering Bulletin No. 5, University of Kansas, entitled, "Water Supplies of Kansas."

*Extract from a paper read at the annual meeting of the Minnesota Engineers' and Surveyors' Society.

Engineering and Contracting

Devoted to the Economics of Civil Engineering Design
and to Methods and Cost of Construction

EDITORS
H. P. Gillette C. S. Hill C. T. Murray S. C. Hadden C. W. Malcolm

Volume XLV. CHICAGO, ILL., MARCH 15, 1916. Number 11.

CONSTRUCTION WORK AND CAR SHORTAGE.

Unless indications are at fault contractors for the coming season's work are bound to experience more than usual trouble because of delayed deliveries by railway. Car shortage of more than commonly serious proportions, it is announced, is likely to prevail for some months and the railways are vigorously urging shippers to co-operate in reducing its effect. Shippers are asked to make every effort to load and unload cars quickly. The average time of loading a car by shipper is two days and of unloading it by consignee is two days, making a total of four days. Reducing this total time one-fourth would materially expedite service. In a recent bulletin the Queen & Crescent Route lists some ways in which shippers and receivers can materially assist in reducing car shortage and these ways put so little burden on shipper and consignee that we quote them here. They are:

By not ordering more cars than are actually needed.

By loading cars as quickly as possible to full capacity and furnishing billing promptly so there will be no delay in starting the car to its destination.

By loading car properly so that it will not be necessary to delay it in transit adjusting the load or transferring it to another car.

By loading or unloading cars as soon as placed, regardless of free time allowance.

By notifying carrier as soon as cars are loaded or made empty and ready to remove.

By not using a box car when a gondola or flat car will serve, as box cars are usually in greater demand.

By endeavoring to have reconsigning orders placed in advance of arrival of car so it may be switched to proper track on arrival instead of being placed on a yard track awaiting disposition.

Contractors will serve their interests by fulfilling these requirements as completely as possible in so far as their end of the line is concerned.

TIMBER FOR MODERN STRUCTURES.

In a manner the engineer has forgotten timber as a structural material. Steel and concrete and clay tile have crowded it out of mind. In part this condition has come from the negligence of the lumberman. He has let his business drift while his competitors handling the rival structural materials named have spared no effort to arouse interest and create a demand for their mineral substitutes. In great measure too these newer materials demand preference because of their superiority for a particular purpose. Timber instead of steel and tile and concrete for the tall building or the great bridge is virtually inconceivable. Another influence that has acted to place timber out of mind for structural uses is the impression that exhaustion of the supply is approaching. For this belief there is less reason than, perhaps, most engineers imagine.

These remarks lead up to the fact, which has lately become manifest, that at present determined effort is being made by lumbermen to reinterest engineers in the use of timber for structural purposes. As a single illustration there is mentioned the series of engineering publications on structural timber being issued by the National Lumber Manufacturers' Association, Chicago, Ill. We believe that engineers will do well to arrange for receipt of these bulletins. The one received by us has a tone of more than usual reasonableness as such special pleas go. In particular it corrects an impression which has gained great strength in recent years that timber exhaustion is imminent and consequently that lumber prices are going soon beyond all bounds. Without depreciation of the good work performed by our timber conservationists it can be truly asserted that this is one of several ways in which they have overplayed their hand.

To return to the question of timber exhaustion and lumber prices it is interesting to review some of the Federal Bureau publications relating to timber. With the present timber stand alone considered it is estimated that, without material change in quality, there is enough untouched forests to supply all probable demands for another half century. What then? it may be asked. Mr. W. B. Greeley and Mr. H. S. Betts of the U. S. Forest Service answer this question as follows: "Long before the present enormous forest resources are eaten up, however, it is more than probable that readjusting economic conditions, particularly higher values for timber and a lower per capita consumption, will reduce the annual drain to an amount not more than the annual growth." It may be remarked also in this connection that generally lumbering operations are today being conducted in a less wasteful manner and that this reform is gaining ground every year. Altogether, so far as timber exhaustion is concerned, the engineer has no great need for withholding his hand from the use of timber wherever it suits his purposes better than or even equally as well as other materials.

Lumber prices are bound to advance. They have advanced in recent years. But lumber prices have shown no undue advance; the price curve is as nearly normal as that of most other materials.

GOOD EVIDENCE OF THE NEUTRALITY OF PUBLIC UTILITY COMMISSIONS.

In the early days of public utility regulation by state commissions the charge was frequently made that such commissions were unfair to the private corporations. Indeed there is little doubt that such a charge was well founded in many cases, particularly in the early months of activity of a newly formed commission. The commissioners, in their zeal to lift the corporation yoke from the neck of the ultimate consumer, erred on the side of the consumer and did substantial injustice to the corporation. That this condition is passing is indicated by the fact that municipalities are now beginning to charge that the commissions favor the corporations.

One of our valued exchanges is the official organ of one national and two state leagues of municipalities. Its latest number is just received, and two of its articles suggested this editorial. One article charges that the state utility commissions waste time. It goes on to say, also, that where a commission fixes a rate the consumer has little or no recourse if the rate is too high, but if the company considers the rate too low it has the right to appeal to the courts. Thus the consumer is entirely at the "mercy" of the commission, while the company is not. Then the statement is made, in the article to which we refer, that the membership of the various state utility commissions is more and more being made up of corporation men.

The second article is entitled: State Utility Commission Hands City Package. Whatever the merits it lacks it possesses the merit of brevity so we quote it here in full:

The Utility Commission of California in a recent order decides that

> it does not have the power to order a private water works company to extend its mains for the purpose of fire protection, but only for the purpose of supplying domestic consumption. A year ago the statement was made by a well-posted student of utility regulation that the California Commission was the only one in the country favorable to the people. It would seem that this commission is now about to join the ranks of the corporation-controlled state utility commissions. Once more a great reform has gone astray. The reformers who forced the utility commissions on the different states ought to be pensioned by the corporations, as they have done a work for the utility companies that the corporations could not do themselves.

Now the whole discussion tots up just to this: the cities charge that the commissions favor the corporations and the corporations charge that the commissions favor the cities. Could any better evidence be deduced that the commissions are acting fairly to both parties? We think not.

SOME SIGNS OF DISTINCT PROGRESS IN ENGINEERING EDUCATION.

At various times Engineering and Contracting has commented editorially on certain tendencies in modern engineering education, and has pointed out some faults possessed quite generally by engineering graduates. The close association of the editors with both practicing engineers and teachers of engineering has furnished convincing evidence that the engineer in practice finds much to criticise in the engineering graduate, and also that, in general, those in charge of our engineering schools are alert to the need for somewhat radical changes. It is evident that the teaching of engineering can never be reduced to fixed rules and set courses, yet the common observance of certain fundamental principles by those in charge of engineering education will act to reduce waste in time, energy and money. In the past, engineering educators have not even been in agreement as to results desired; some evidently believed that the function of the engineering school was to produce graduates who could immediately command high salaries; others were content to leave to the employer the teaching of specific details. We believe there never has been a time when engineering educators and employers of engineering graduates have been so close together in their views as at present; and there is plenty of evidence to support this contention.

Until recently, there never has been a concerted attempt to determine the views of those most directly concerned in the problems of engineering education, and we are therefore indebted to the Carnegie Foundation for the Advancement of Teaching for undertaking a task of such magnitude. Although only preliminary work in the way of collecting and interpreting data has been done to date it is already evident that the efforts of the Foundation will be fruitful. In collecting pertinent data those in charge of the investigation not only have interviewed practicing engineers and teachers of engineering, but have circularized the entire membership of the four national engineering societies. In a recent progress report Mr. C. R. Mann, of the Foundation, has given some impressions gained from a brief examination of the information already at hand. These preliminary conclusions may be summarized as follows:

In questioning the efficiency of our engineering schools there are four conspicuous points in which professional men show a fair degree of unanimity. The first and most striking professional criticism concerns the graduate's lack of training in English. A second point which is prominent in the professional criticism of engineering schools is the engineer's breadth of view. A third important point is the lack of what may be termed business sense. The fourth and perhaps the most important point on which members of the engineering profession agree in criticising schools may be called over-specialization. These four points present the most comprehensive problems now facing the engineering schools, as seen by those who have the opportunity of observing the way in which engineering graduates function in practice.

We believe the above is a fair statement of the views at present held by the great majority of those now engaged in engineering instruction. In fact many schools have already taken steps to correct some of the defects implied by the criticisms given above, notably over-specialization, and lack of training in English. We doubt, however, if the average teaching force—by teaching force we mean the men who do the actual teaching work—possesses the wide experience and ability necessary to impart to their students breadth of view and business sense. Unfortunately, those of our teaching staffs who are best qualified for this work do little teaching, their time being taken up largely in administrative work and in general publicity work. The inducements offered to men qualified for effective teaching are still inadequate to attract a sufficient number of high grade men, the result being that, in general, the men now occupying these positions are not under the spur of active competition. It is gratifying to note, however, that the compensation of engineering teachers has increased materially in the past few years, and the time seems not far distant when teaching will be a life-long job only for the man of exceptional natural ability and professional training.

WHAT'S THIS?

In a recent issue a valued exchange publishes a full page advertisement of a new septic tank company and of the new septic tank company's new septic tank. The advertisement illustrates a residential installation. The tank appears, to our more or less practiced eye, to be very closely akin to the general run of residential septic tanks which have been installed at so many places in this country during the past 20 years. It is a two-compartment, one-story tank. The first compartment has two baffle walls and beneath these, in the picture, appears the word "microbes." The effluent from the first compartment siphons over into the second. The latter compartment has a thin vertical charcoal-filter wall at its center, the charcoal being held in place by wire mesh. That is the layout; in brief, here are the claims made for it:

> The scientific disposal of sewage is no longer a problem. Constructed with scientific exactness throughout, the Blank Sanitary Septic Tank is meeting the constant approval of civil and sanitary engineers and architects throughout the United States. These tanks have been declared by high authorities as the last word in sewage elimination.
>
> Sanitary engineers are offered this sure solution of the problem of eliminating vaults and cesspools which pollute the air, surrounding wells and water courses. Nearly all, if not all, the epidemics of typhoid fever, diphtheria and other diseases far too numerous to mention, are directly traceable to so-called sewage disposals, such as vaults and cesspools that are centuries out of date. Scarlet fever and malignant malaria also are spread by sewage that is not scientifically neutralized. This condition must be corrected by the Man Who Knows. The cost of the remedy is out of all proportion to the manifold danger of carelessness. Simple in design, Blank Sanitary Septic Tank is surprisingly low priced. And the first cost is the only cost.
>
> They are absolutely indestructible, being built by our own force of trained construction engineers, of reinforced concrete. No cleaning is necessary. No expense for up-keep. They cannot become stopped up and we guarantee every structure for a long number of years. The process of sewage elimination is brought about by nature, aided by the Blank Sanitary Septic Tank through the agency of the cultivation of the bacteria known as the anerobe. Harmless to humanity, it feeds upon the dangerous disease breeding bacteria in all raw sewage, and by doing so brings about perfect septication, hence the perfect elimination of human excreta.
>
> The overflow or effluent from the Blank Sanitary Septic Tank or Blank Sanitary Sewage Disposal Plant is harmless in every particular, and may be drained into a ravine or open ditch with perfect safety.

The advertisement closes as follows: "Estimates Gotten Up and Engineers Furnished for All Occasions. Responsible Agents Wanted in United States and All Foreign Countries Covered by United States and Foreign Patents."

In fairness to the editor of the journal from whose advertising pages we quote it should be stated that he has on at least one public occasion, argued very plausibly that advertising copy should be censored by the editorial department. His case is now complete.

One other thought and we are off this distressing subject. The reader can not have failed to note that this new septic tank is covered by patents. If memory serves us the Cameron Septic Tank Co. also patented the septic process some time ago. We foresee a conflict of interests here. A meeting should be arranged so that those who have conflicting claims on the services of the Hon. Bacterium Anerobe may have a chance to compose their differences. And where shall the meeting be? We suggest the Island of Tutuila. The ayes appear to have it.

EDITORIAL PARAGRAPHS.

Letters from subscribers are a desired and a desirable feature of an engineering journal. And by choosing his subjects for discussion the editor can always incite this correspondence. A comment on engineering ethics, on compensation of engineers, on specification writing, on pavement guarantee clauses, on a new mathematical theory will find its reader ready to "take pen in hand" and tell the editor how sound are his ideas or wherein they are vitally wrong. But a comment on gang organization or on a method of erecting steel or building forms or depositing concrete or loading wagons rarely causes any addition to the editor's mail. Meet face to face the man who knows how to load dump wagons quickly or how to do well the other practical tasks named and he is found vocally proficient. But he will not write to the editor and 'tis a pity.

Many inventions for obstructing good roads propaganda have been charged to the tiller of the soil but the Missouri Highway Department voices a unique complaint. Various farmers along the main traveled ways of the "show me" state not only resent their elimination but take pains to preserve mudholes so that they may trap the unwary automobilist and gather some shekels by pulling him out of his gumbo bed. The Highway Department thinks that money thus earned should be turned into the state road fund. The farmers haven't reported what they think.

A certain well-known railway system has created a new office which is said to be the first of its kind in the history of American railroading. The officer's official title is welfare agent. He is, we read, a preacher of the Methodist persuasion. The office was created for the purpose of providing the road's employes better opportunities for moral, social and industrial uplift. He will also act in the nature of a diplomat, it is said. We thought likely there was a catch in it somewhere. It does not allay this suspicion to learn, as we do by reading further, that before becoming a preacher he was a lawyer and served a term in a state legislature.

Close observers of the progress in water treatment for municipalities state that we are entering on an era of close attention to the treatment of water from other than the hygienic standpoint. Without relaxing our vigilance on the latter point we are going to give more and more attention to the treatment of water which, while pure, has objectionable characteristics. Thus, many ground waters will be treated for the removal of iron and manganese, and many water softening plants will be installed. In an early issue we shall publish an article which gives performance and cost data on the operation of a water softening plant at the village of Hinsdale, Ill. This is a village of only 3,000 population, yet it found it could afford softened water.

Mr. C. R. Ashbee, a fellow of the Royal Institute of British Architects, recently stated, in an address in St. Louis, that an ideal city in which to live should not have more than 10,000 inhabitants. He went on to say that a city with 10,000 residents can support every kind of institution which can contribute to the comfort of its people. Those in larger cities face the problem of making their cities over if they would have them beautiful and comfortable. How many will do that, assuming that our British friend is right? Not many, we fear. While we desire nothing so much as to appear progressive in all things, we confess to a certain degree of skepticism about the practicability of the city planning movement. Did it not arrive about 100 years too late, or did it?

FORMULAS FOR DETERMINING THE PRESSURES ON PILES SUPPORTING MASONRY.

To the Editors:—The article published in the Nov. 17, 1915, issue of Engineering and Contracting entitled "Pressure on Piles Supporting Masonry" suggests to the writer the following method of determining the spacing of piles for such structures so that each pile will receive the same load:

Referring to Figs. 1, 2 and 3, let

V = the vertical component, per lineal foot of foundation, of the resultant of the loads to be supported by the piles,

L = width of base,

e = the eccentricity,

p = pressure per square foot at the toe, and

p′ = pressure per square foot at the heel.

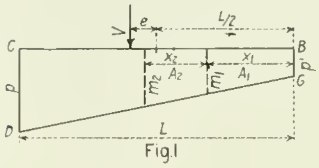


Fig.1

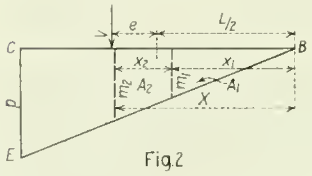


Fig.2

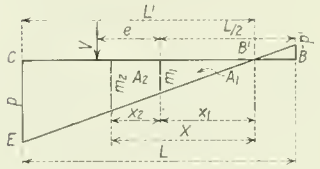


Fig.3

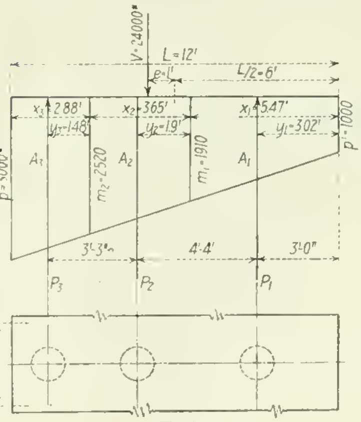


Fig.4

Figs. 1-3 — Diagrams Illustrating Three Cases Considered in Determining Pressures on Piles Supporting Masonry. Fig. 4—Example Used to Illustrate Method of Determining Pressures on Piles Supporting Masonry.

From the well known formula we have

$$p = \frac{V}{L} + \frac{6Ve}{L^2}, \quad \ldots\ldots (1)$$

$$p' = \frac{V}{L} - \frac{6Ve}{L^2} \quad \ldots\ldots (2)$$

The areas C D G B, C E B and C E B′ (Figs. 1, 2 and 3, respectively) represent the total upward pressure on the base per lineal foot of foundation when $\frac{V}{L}$ is greater, equal to, and less than $\frac{6Ve}{L^2}$.

If P is the bearing value of a pile then the number of piles required per lineal foot of foundation is

$$n = \frac{V}{P}, \quad \ldots\ldots\ldots\ldots (3)$$

or, if A denotes the area C D G B, C E B, or C E B′, as the case may be,

$$n = \frac{A}{P} \quad \ldots\ldots\ldots\ldots (4)$$

The width of a strip of foundation supported by a row of piles is

$$S = \frac{N}{n}, \quad \ldots\ldots\ldots\ldots (5)$$

where N is the assumed number of piles in a row. N should be assumed so that S will not be less than the minimum spacing allowed to drive the piles.

Now, if A is divided into N equal parts as A_1, A_2, etc., and a pile is placed at the center of gravity of each division, then each pile will receive the same load. The spacing in the other direction is the value of S found from equation (5).

Case I.—To divide A into N equal parts, when A is as shown in Fig. 1, we have the following formulas:

$$\frac{p - p'}{2L} x_1^2 + p'x_1 - A_1 = 0, \quad \ldots\ldots\ldots\ldots\ldots\ldots (6)$$

where A_1 is equal to $\frac{A}{N}$.

$$m_1 = p' + \frac{p - p'}{L} x_1, \quad \dots\dots\dots\dots\dots\dots\dots\dots \quad (7)$$

in which x_1 is readily found from the formula

$$x_1 = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}, \quad \dots\dots\dots\dots\dots\dots\dots \quad (8)$$

where $a = \frac{p - p'}{2L}$,

$b = p'$,

and $c = A_1$.

To find x_2 and m_2 formulas (6) and (7) are used, remembering that p' is to be replaced by m_1, and L by $(L - x_1)$.

In like manner, the equations (6) and (7) are applied until the required division is completed.

Case II.—If A is in the form shown by Fig. 2, formula (6) reduces to

$$x_1 = \sqrt{\frac{2A_1L}{p}} \quad \dots\dots\dots\dots\dots\dots\dots\dots\dots \quad (9)$$

and formula (8) to

$$m_1 = \frac{px_1}{L}, \quad \dots\dots\dots\dots\dots\dots\dots\dots\dots \quad (10)$$

for the first division.

For the remaining divisions formulas (6) and (7) may be applied, or the total length X can be found by making the proper substitution and applying formula (9); x_2 then equals $(X - x_1)$, and $m_2 = \frac{pX}{L}$, the same method being applied until the required number of divisions is obtained.

Case III.—Formulas (9) and (10) are applicable to this case when L^1 is substituted for L (see Fig. 3).

Example.—As an illustration of the foregoing method the following example is given:

Referring to Fig. 4, let

$V = 24{,}000$ lb. per lineal foot of foundation,

$L = 12$ ft.,

$e = 1$ ft., and

$P = 24{,}000$ lb. = bearing value of a pile.

From formulas (1) and (2),

$$p = \frac{24{,}000}{12} + \frac{6 \times 24{,}000 \times 1}{12^2} = 3{,}000 \text{ lb. per square foot,}$$

and

$$p' = \frac{24{,}000}{12} - \frac{6 \times 24{,}000 \times 1}{12^2} = 1{,}000 \text{ lb. per square foot.}$$

From formulas (3) and (5) (assuming $N = 3$ piles),

$$n = \frac{24{,}000}{24{,}000} = 1 \text{ pile per lineal foot.}$$

$$s = \frac{3}{1} = 3 \text{ ft.}$$

$$a = \frac{p - p'}{2L} = \frac{3{,}000 - 1{,}000}{2 \times 12} = 83.5.$$

$$b = p' = 1{,}000.$$

$$c = A_1 = \frac{24{,}000}{3} = 8{,}000.$$

From formula (8) we have

$$x_1 = \frac{-1{,}000 \pm \sqrt{1{,}000^2 + 4 \times 83.5 \times 8{,}000}}{2 \times 83.5} = 5.47 \text{ ft.}$$

From formula (7),

$$m_1 = 1{,}000 + \frac{3{,}000 - 1{,}000}{12} \times 5.47 = 1{,}910.$$

For x_2,

$$a = \frac{p - m_1}{2(L - x_1)} = \frac{3{,}000 - 1{,}910}{2(12 - 5.47)} = 83.5,$$

$b = 1{,}910$ and $c = A_2 = 8{,}000$.

Note that a is constant.

$$x_2 = \frac{-1{,}910 \pm \sqrt{1{,}910^2 + 4 \times 83.5 \times 8{,}000}}{2 \times 83.5} = 3.65 \text{ ft.}$$

$$m_2 = 1{,}910 + \frac{3{,}000 - 1{,}910}{6.53} \times 3.65 = 2{,}520.$$

$$x_3 = 12 - 5.47 - 3.65 = 2.88 \text{ ft.}$$

From the formula for the center of gravity of a trapezoid we have

$$y_1 = \frac{1{,}000 + 2 \times 1{,}910}{1{,}000 + 1{,}910} \times \frac{5.47}{3} = 3.02 \text{ ft.}$$

$$y_2 = \frac{1{,}910 + 2 \times 2{,}520}{1{,}910 + 2{,}520} \times \frac{3.65}{3} = 1.9 \text{ ft.}$$

$$y_3 = \frac{2{,}520 + 2 \times 3{,}000}{3{,}000 + 2{,}520} \times \frac{2.88}{3} = 1.48 \text{ ft.}$$

Using the values of y_1, y_2 and y_3 and spacing the piles to the nearest inch we have the spacing required so that P_1, P_2, and P_3 will receive equal loads.

Very truly yours,

J. R. Biedinger,

Designing Engineer, Department of Structures.

Cincinnati, O., Feb. 9, 1916.

SOME MAINTENANCE COSTS OF NEW YORK STATE ROADS.*

By H. E. Breed, Deputy New York Commissioner of Highways.

The maintenance charge for 238 miles of brick highways for the year 1915 was $41,240, or approximately $176 per mile per year. This amount was increased to a large extent by a number of older pavements which had many replacements. If we eliminate those we find that we have 107.91 miles of brick pavement which cost $14,185 to maintain and repair. This is at a cost of approximately $131 per mile. These figures, as we mentioned at first, are not the figures from the pavement alone, and they include such treatment as cleaning ditches, cost of patrol where patrol was needed, fixing the shoulders which are cut up by the turning out of traffic, the cleaning of slides and maintaining of guard rail. From observation I think it would be safe to say that about 30 per cent to 40 per cent of this cost is the average cost that would cover the maintenance of the pavement alone, although in some cases for a series of years there is practically no cost to the pavement proper.

With these figures it may be interesting to note the cost of maintenance of other types of pavement during the same year, computed on the same basis as that for the brick roads—i. e., including the maintenance of guard rail, shoulders, ditches, patrol, etc., as well as the surfacing.

For gravel we find that it cost $577 per mile for 192 miles of road; for waterbound macadam we find that it cost $564 per mile for 2,298 miles of road; for penetration method bituminous macadam we find that it cost $448 per mile for 2,387 miles of road; for bituminous macadam mixed method it cost $181 per mile for 63 miles or road; for second-class concrete roads requiring surface treatment it cost $532 per mile for 295 miles of road; for cement concrete pavement 1-1½-3 mix it cost $129 per mile for 84 miles of road.

Scoring Railway Maintenance Work.—On the Southern Pacific System the basis of scoring is as follows: 25 points for spiking ties, lining and spacing of switches and frogs; 25 for alignment, surface and gage of track; 20 for drainage and ballast; 10 for material, lack of grass and weeds, and general condition of the right-of-way; 10 for sidings; 10 for fencings, road crossings, etc. This year the Sacramento Division was high with a grade of 92.73.

---

*Extract from a paper read at the Pittsburgh meeting of the American Road Builders' Association.

A REVIEW OF RECORDS OF REINFORCED CONCRETE INVERTED SIPHON CONSTRUCTION.

III.

Inverted siphons of major size are considered. These are confined to long line aqueducts for domestic water supply or for irrigation. An inverted siphon is introduced into aqueduct only when a depression or a stream is crossed. Reinforced concrete construction is not commonly employed. Usually the crossing is made by flume on trestle, by steel pipe siphon or by deep tunnels. The records from which to draw information of reinforced concrete siphon construction are therefore few in number. As siphons of major size only are considered in this review, the number of examples available for study and comparison is reduced still further. For mention the writer finds less than a dozen structures and details are recorded of only half of these. A greater number than is mentioned of reinforced concrete siphons has been constructed but the methods of constructing them have not been recorded in any detail.

Selected Examples.

The most notable reinforced concrete siphons in the United States are those on the Los Angeles Aqueduct and those built for various irrigation works of the U. S. Reclamation Service. For illustration there has been selected two examples from the Los Angeles aqueduct and three examples from the Reclamation Service work.

Los Angeles Aqueduct.

On the Los Angeles aqueduct there are 2.65 miles of reinforced concrete siphon, all 10 ft. in diameter and none having a pressure exceeding 75 ft. head of water.

Whitney Siphon.—This siphon, 955 ft. long and having a pressure head of 70 ft. was built as an experiment to determine the success of the construction planned. Figure 1 indicates the section and shows the form construction. After the trench was excavated to line and grade the first operation in the construction of the siphon proper was setting the concrete blocks to support the inner forms. These blocks, which were 4 in. thick, 10 in. wide and about 12 in. high, had been made a few weeks previous to allow ample time for hardening. The tops were cast to fit the curve of the inner forms. They were spaced 6 ft. apart in two parallel rows, so that each pair supported a 6-ft. length of the inner forms. They were set in mortar a few days before the forms were placed on them. This arrangement not only insured correct alignment and grade, but permitted the concrete to be readily poured and thoroughly spaded. The concrete blocks became a part of the concrete shell of the siphon.

The next step was the setting of the inner forms, which were of wood and not very satisfactory, as it was difficult to maintain them in a circular shape after they were once moved. Each 6-ft. length of forms was made up of eight sections, three below the horizontal diameter and five above it, braced and bolted in such a way that they could be collapsed for moving ahead (see Fig. 1). Each section was made of four ribs cut to the proper curve, on which the 2-in. lagging was nailed. The lagging was dressed on the outer side. The arrangement of the cross braces which held the sections in place permitted the dismantled sections to be moved ahead through those already erected, by means of a platform car on a track which rested on the cross ribs of the bottom section. The car was pulled back and forth with a rope. In conjunction with the setting of the inner forms the reinforcement rods were placed on them, having been previously bent to the required circle with a small bending machine, and properly spaced, wired and blocked away from the forms. After the inner forms were assembled, circular ribs were placed to support the outside lagging. These were spaced 4 ft. apart and braced against the side of the trench. The outside lagging was 2x6x4 in.

The concrete was commenced near the middle and carried first toward one end and later toward the other. There were 120 lin. ft. of inner forms used. They were set up by a crew of 8 men. When everything was in readiness one of the regular tunnel concrete crews of 26 men and a foreman were detailed to the work. From 36 to 40 men were required to keep the work going continuously. The concrete was delivered on top of the forms through a chute, and flowed to the bottom over them. The outside lagging was placed about 2 ft. high at the start, to allow room for inspection and spading on the bottom. As the concrete rose in the forms, more lagging was placed. The bottom of the trench was filled for the whole length of the day's run and the complete pipe was finished the same day, whether it was 30 ft. or 50 ft. A rough connection was made by means of a sand bag bulkhead, and particular pains were taken to insure a good bond at this point. About three days were required to complete the 120-ft. pipe. About noon of the second day the work of taking down the inner forms and moving them ahead was begun, without interfering with the progress of the concreting. In about 24 hours the outer forms were removed and the pipe was immediately backfilled and thoroughly flooded for about a week. When the foot of the steep slope was reached the mixer was moved to the top of the slope and the work continued in the same way until the top was reached. At each end of the siphon a manhole 30x36 in. was constructed. Electrical energy was used for light and power and water was supplied under pressure from a large tank on the adjacent hill. Sand and gravel were obtained from the adjacent creek without screening. All stone larger than 3-in. was rejected. The mix was 1:4 or 1 bbl. of cement to 16 cu. ft. of concrete. About 20 per cent of water was used, which insured a very wet mix. The costs were:

Item.	Per lin. ft.
Excavation	5.47
Concrete lining	8.33
Steel in place	3.82
Backfill	2.63
Engineering	0.13
Anchorage proportion	0.14
Blowoff proportion	1.28
Average cost per lin. ft. completed section	$21.80
Average labor cost mixing and placing per lin. ft.	2.14
Average labor cost placing steel per lin. ft.	0.83
Average cost per ft. for forms	1.20

As there are about 0.78 cu. yd. of concrete per lineal foot of this siphon any of the above items multiplied by this sum gives cost per cubic yard of concrete. The successful testing of this siphon decided the construction of others as planned. A description of one of these follows:

Antelope Valley Siphon.—This siphon is a composite structure having a middle portion of steel pipe and two end portions, respectively, 3,446 ft. and 2,734 ft. long, of 10-ft. reinforced concrete conduit of the standard section indicated by Fig. 1. The maximum head on the concrete pipe was about 75 ft.

The average progress was 44 ft. per day. After the first week a rate of 40 ft. was maintained for about 20 days, after which a uniform rate of 49 ft. per day was made until completion. The inner forms were of wood built up in sections about 20 ins. wide and 4 ft. long, supported by collapsible steel ribs. These were much more satisfactory than the wooden forms used on the Whitney siphon. The working force on the concrete was as follows: 1 superintendent, 1 concrete foreman, 6 men charging mixer with wheelbarrows, 1 man on cement, 1 man running mixer, 5 men placing, 6 bending and placing steel and setting outside ribs, 4 men taking down inside forms, 4 men setting up inside forms, 1 man trimming bottom and setting concrete blocks to support inner forms, 2 plasterers, 2 plasterers' helpers. Total, 32 men. The average rate of pay for this force was about $2.75 per day, or a labor cost of $2 per lineal foot on the basis of 44 ft. progress for mixing and placing, moving and setting forms and finishing. Rock for a large part of the work was hauled 7½ miles from a plant in the hills and the average haul for sand was 1½ miles. Cement and steel were hauled by teams from Lancaster on the Southern Pacific R. R., a distance of 36 miles. Monolith Tufa cement, manufactured by the city of Los Angeles, was used in the ratio of 7 sacks per cubic yard of concrete. The details of cost for the 3,446 ft. of pipe are as follows:

	Per lin. ft.	Per cu. yd.
Excavation	$0.94	.....
Sand and gravel	0.606	$0.45
Rock	3.07	2.32
Cement	5.80	4.37
Mixing and placing	0.91	0.69
Moving forms	0.62	0.47
Plastering	0.26	.....
Steel in place	4.30	.....
Backfill	0.39	.....
Engineering (instrument work)	0.04	.....
Superintendence	0.26	.....
Total per lin. ft.	$17.20	.....

The above does not include the cost of forms; it will approximate $1 per ft.

Reclamation Service Siphons.

No record is had of the number of siphons constructed by the Reclamation Service. Including those of small size it is large. The siphons of major size are few, however, and those selected as examples represent construction practice adequately.

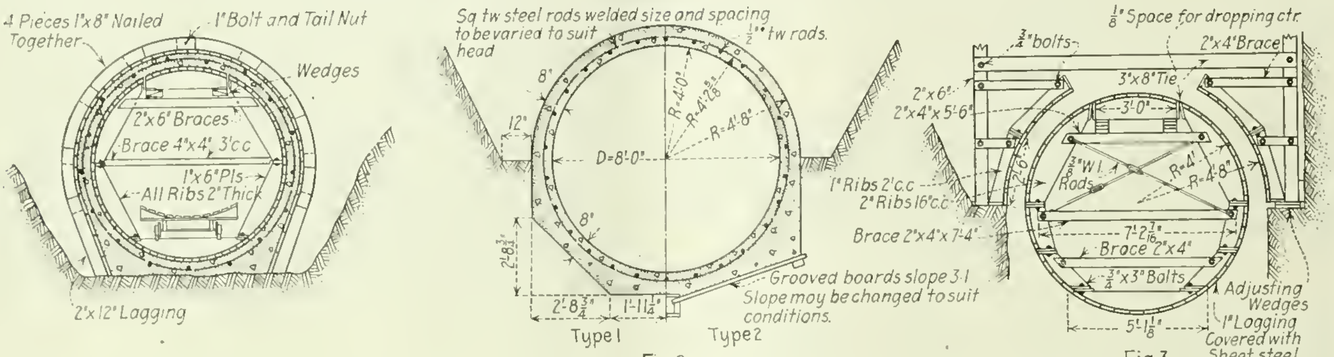


Fig. 1—Whitney Siphon. Fig. 2—Section of Belle Fourche Siphon. Fig. 3—Forms for Belle Fourche Siphcn.

Belle Fourche Siphons.—There was built three siphons on this project: One 8 ft. in diameter and 477 ft. long; one 6 ft. in diameter and 395 ft. long, and one 5 ft. in diameter and 3,565 ft. long. Figure 2 shows a section of the 8-ft. siphon; the sections for the smaller siphons were similar. A 1:2:4 machine-mixed concrete was used; sand being screened to pass a ¼-in. screen and stone being screened to pass a 1-in. ring and be retained on a ¼-in. screen. All siphons were built in trench excavated carefully to the outside form of the siphons. Figure 3 shows the form for the 8-ft. siphon. For the 5-ft. siphon a Blaw collapsible steel form was used. This siphon is recorded in detail as follows: The reinforcement consisted of 304,956 lb. of twisted steel bars; cost per pound Belle Fourche 2.4 ct., plus cost for hauling and storing of ½ ct. per pound. Cement at Belle Fourche cost $2.15 and $2.43 per barrel; hauling and storing cost, $1.28 per cubic yard of concrete. Cement hauled 16 miles; gravel hauled 1 mile. Wages per 8-hour day averaged $2.44, one foreman at $2.25 and one at $100 per month. Weather conditions favorable. Costs of concrete work alone were:

Item.	Per cu. yd.
Preparatory expenses	$0.30
Plant depreciation	0.43
Administration	1.03
Engineering	0.29
Superintendence	0.42
Inspection	0.06
Camp maintenance	0.32
Water work	0.28
Blacksmith and carpenter shop	0.26
Total general	$3.39
Crushing and screening	$1.40
Hauling gravel and sand	0.50
Building (including lumber) wood forms	0.84
Hauling lumber for forms	0.18
Erecting steel forms	0.47
Miscellanéous	0.32
Cleaning reinforcement	0.08
Bending and welding	0.30
Mixing concrete	0.53
Placing concrete	0.42
Finishing and watering	0.22
Total labor	$5.26
Cement	$3.67
Steel	3.26
Hauling and storing cement	1.28
Hauling and placing steel	0.73
Miscellaneous	0.30
Total	$9.24
Rent of steel centering	0.86
Miscellaneous supplies	0.17
Total concrete	$18.92

The distribution of labor and materials costs it will be noted is not precise and totals for these items are therefore slightly in error; final total is accurate. The total cost of the concrete work proper was $41,929; the total cost of the siphon, including excavation, filling equipment, etc., was $59,310. Costs recorded in 1908; reported by U. S. Reclamation Service.

Sun River Siphon.—This work was a reinforced concrete siphon 1,568 ft. long, inside diameter 5 ft. 3½ in., with concrete piers and intake built for Sun River project U. S. Reclamation Service. Concrete, 613 cu. yd. in siphon and 272 cu. yd. in piers and intake, 1-2-4 mixtures. Wages were per eight-hour day for laborers, $2.24 to $2.74, two foremen at $125 per month, one carpenter foreman at $5.50 per day and carpenters at $3.50 per day. Cement cost $5.60 per barrel and reinforcing steel 4.12 ct. per pound, delivered. Work done by day labor; weather favorable. Sand and gravel hauled 2 miles; cement and reinforcing steel hauled 27 miles. Forms collapsible steel; progress 18 lin. ft. per day. Costs covering concrete work only were:

Item.	Per cu. yd.	Per cu. yd.
Amount of concrete, cu. yd.	Pipe, 613	Piers, etc., 272
Engineering	$2.09	$1.57
Superintendence	1.26	0.95
Preparatory expenses	0.38	0.67
Administration	3.47	2.61
Camp maintenance	0.96	1.09
Total general	$8.16	$6.89
Hauling sand and gravel	2.91	2.85
Handling cement and steel	0.27	0.30
Hauling, wood, water and miscellaneous	0.26	0.40
Pumping	.....	1.85
Making forms	1.85	2.03
Bending and placing steel	1.43	0.31
Mixing and placing concrete	3.32	2.35
Moving forms	1.40	0.41
Building trestle	0.25	.....
Total labor	$11.69	$10.50
Lumber	1.41	1.59
Steel	4.10	4.06
Cement	6.35	4.90
Total materials	$11.86	$10.55
Steel forms and supplies	$0.81	.....
Installing and removing plant	0.28	$0.21
Depreciation	0.47	0.52
Miscellaneous	1.32	1.49
Corral expenses	0.40	0.45
Total supplies	$ 3.28	$ 2.67
Total concrete	34.99	32.16

There were 1,254 ft. of tile underdrain which cost 81 ct. per lineal foot, and charges for excavation, backfilling rip-rap, survey and design, depreciation of buildings aggregating about $7,000, making the total cost of the siphon $23.49 per lineal foot. Costs recorded in 1907-8; reported by U. S. Reclacation Service.

Salt River Siphons.—Two twin-tube siphons were constructed, one under Pinto Creek 2,130 ft. long under 35 ft. head and one at Cottonwood Canyon 250 ft. long under a head of 76 ft. A cross-section of one of the Pinto Creek tubes is shown by Fig. 4. The concrete was a 1:2½:4 mixture, mixed wet by hand. The novel feature of the work was the use of a traveling form.

The forms consisted of an outside form constructed as shown by Fig. 4, by inserting 2½-in. x 5½-ft. lagging strips in the metal ribs. The inside form was designed to permit continuous work by moving the form ahead as the concreting progressed. It consisted as shown by Fig.

4, of an invert form on which an arch form was carried on rollers. The invert form was pulled along by cable from a horsepower whim set ahead, being steered, aligned and kept to grade by being slid on a light wooden track. It had the form of a long half cylinder, with its forward end beveled off to form a scoop-like snout. The arch center consisted of semi-circular rings 2 ft. long, set one at a time as the work required. Each ring, when set, was flange-bolted to the one behind, and each was hinged at three points on the circumference to make it collapsible. In operation, the invert form was intended to be pulled ahead and the arch rings to be placed one after another in practically a continuous process. So that the arch rings might continue supported after the invert form was drawn out from under them, invert plates similar to the arch plates were inserted one after another in place of the shell of the invert form. The plan provided very nicely for continuous work, but continuous work was found impracticable for all but about 2,500 ft. of the 6,000 ft. of conduit built. The reason for this seems to have been at least in a great measure, the slow setting cement made at the cement works established by the Government, at Roosevelt. In building the first 300 ft. of conduit, a commercial cement was used and a progress of 120 lin. ft. of pipe per 24 hours was easily made. This work was done in June. Later, but still in warm weather, using the Government cement and 70 ft. of arch plates, not more than 70 ft. of pipe could be completed in 24 hours; if the plates were taken down sooner, patches of concrete fell out or peeled off with them. As the weather grew colder, this difficulty increased, until finally, the idea of continuous work was abandoned and for some 3,500 ft. of conduit only one 8-hour shift per day was worked. In December and January the plates had to remain in place three days, so that the progress was only 24 ft. per day; in warm weather this rate was increased to 40 ft. per day.

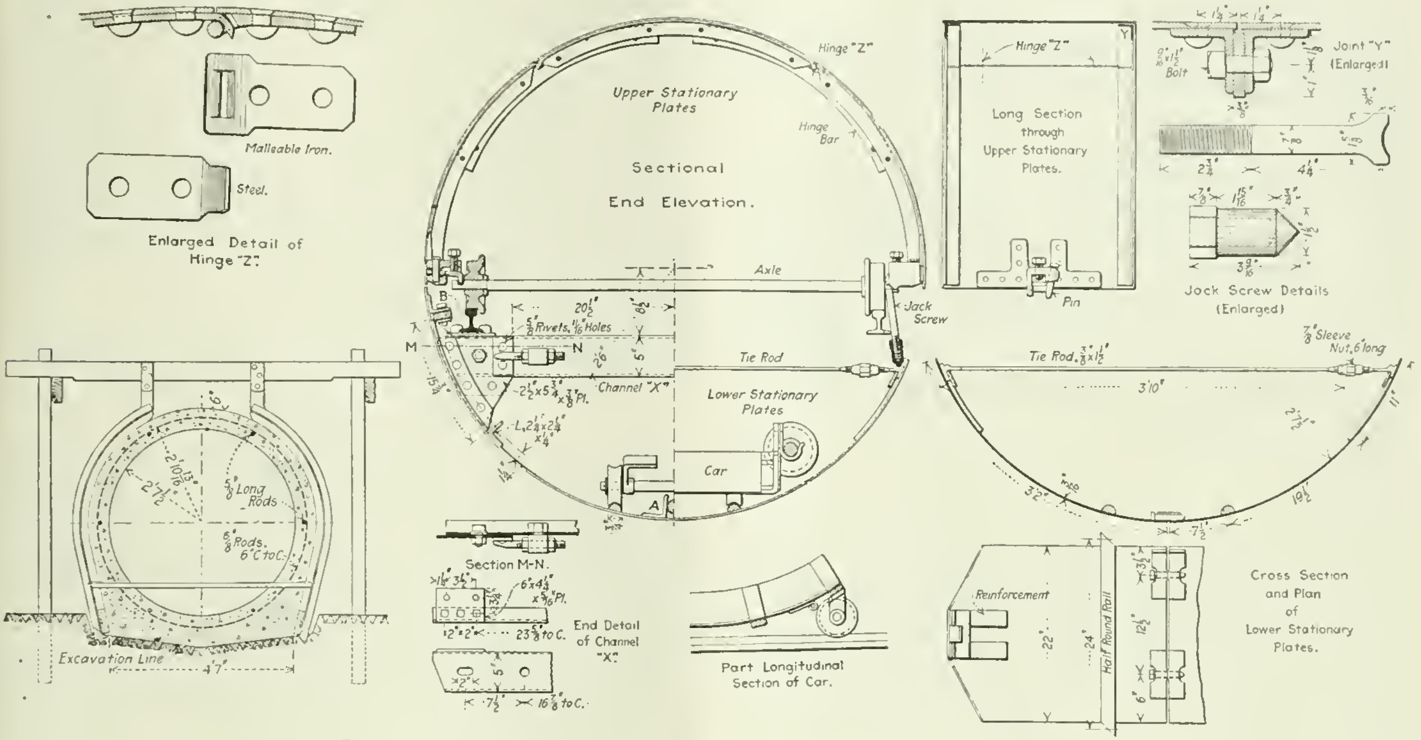


Fig. 4—Section of and Detail of Traveling Form for Salt River Siphons.

Costs were kept on two sections of one of the lines and the figures shown in the accompanying table were obtained. A gang consisted of a foreman at $175 per month, a subforeman at $3.50 per day, and the following laborers at $2.50 per day; one bending the reinforcement rings; two placing the reinforcement; four taking down, moving and erecting the stationary plates; four placing the concrete and outside lagging; two wheeling concrete; six mixing concrete; one, wheeling sand and gravel; one, watering the finished pipe; four, laying track for the steering apparatus, moving the superstructure and hangers, mixing boards, runways, etc.; one pointing and finishing inside the pipe; and one on the whim and doing miscellaneous work. The labor was principally Mexican, and only fairly efficient. It is important to note that the costs in the table are labor costs only of mixing and placing concrete and moving forms; they do not include engineering, first cost of forms, concrete materials, reinforcement or grading.

	Wages per day.	Cost per lin. ft.	Cost per cu. yd.
4 men—			
Laying track for steering alligator	$5.00	$0.0670	$0.16
Moving and erecting superstructure	5.00	0.3821	0.93
4 men moving plates	10.00	0.2646	0.65
Repairs to alligator	....	0.0354	0.08
1 man bending rings	2.50	0.0538	0.13
2 men placing reinforcement	5.00	0.1538	0.38
12 men mixing and placing concrete	30.00	0.9631	2.34
1 man watering finished pipe	2.50	0.0716	0.17
1 man painting and brush-coating inside	2.50	0.1241	0.31
Blacksmith's work	....	0.0319	0.08
1 man whim	2.50	0.0306	0.07
1 man screening and hauling sand and gravel	2.50	0.2804	0.68
Total	....	$2.4584	$5.98

Discussion.

The preceding examples of reinforced concrete siphons are particularly notable for the itemized costs presented. In detail, the Whitney and Antelupe Valley siphons are notable because of their great diameter—10 ft. No other siphon in America of concrete is so large as those constructed for the Los Angeles Aqueduct. Abroad, B. A. Etchverry, in his most valuable "Irrigation Practice and Engineering," records the Albelda siphon, 2,363 ft. long and 13.12 in diameter, with a pressure head of 97 ft. No details of the construction methods employed on this notable Spanish siphon have been found. The Sun River and Belle Fourche siphons are noteworthy for the very complete cost records and as exemplifying the use of metal forms. The traveling form is the one point of great interest in the Salt River construction.

Concrete.—Concrete proportions for siphon construction average, in the records given, about the same as those for reinforced concrete building work. The Reclamation Service has adhered quite closely to about a 1:2:4 mixture. On the Los Angeles Aqueduct, using the home manufactured Tufa cement and a gravel-sand mixture, the proportions were 1:4. For the Spanish siphon noted above the proportions were 1:1.28:2.56. Placing is a task requiring care. The form spaces to be filled are narrow; filling is obstructed by rather close spacing of reinforcement; filling under form bottoms is uncertain unless very closely watched. To overcome these obstacles a wet mixture with a moderately small aggregate is employed, and particular care is exercised in mixing and placing. From the records given one may separate the following costs for mixing and placing:

Example.	Per cu. yd.
Whitney	$1.67
Antelope Valley	0.92
Bell Fourche	0.95
Sun River	2.35
Salt River	2.34

These costs are not completely comparable; they perhaps represent fairly the extremes that may be expected in concreting reinforced siphons. It deserves to be noted, perhaps, that full-circle concreting was practiced in all the siphons described.

Reinforcement.—Fabricating and placing reinforcement are more exacting tasks in concrete siphon construction than they are in most other kinds of concrete construction. Where practicable fabrication; that is, cutting, bending and welding, of hoops is best done at the factory or at central shops on the work. Erection of hoops and connection of longitudinals are necessarily field tasks. This work is not intricate, but it is often tedious and it always demands care. It is therefore expensive work. The following separated costs are an indication of extremes:

Example.	Per cu. yd.
Whitney	$0.65
Belle Fourche	1.48
Sun River	0.31
Salt River	0.51

These are costs for bending and placing alone. Reinforcement in place costs, in the examples recorded, from $3 to $6 per cubic yard of concrete. The handling of reinforcement is, altogether, a task of magnitude. On the Belle Fourche siphon, for example, over 152 tons of reinforcing bars had to be handled, formed and erected. The weight of bars per foot of siphon was 85½ lbs.; this is slightly less than the weight of a steel pipe of the same diameter of 1/6-in. plate.

Forms.—Separated as completely as is possible from the cost records given the costs of forms are about as follows:

Example.	Per cu. yd.
Whitney	$0.94
Antelope Valley	1.96
Belle Fourche	1.33
Sun River	2.44
Salt River	1.82

The figure for Salt River does not include first cost of forms and at Belle Fourche the first cost is assumed to be the retail charge. Roughly, forms cost from $1 to $2.50 per cubic yard. These figures are for the usual collapsible portable types of forms. No cost is found of the traveling form used at Salt River; the labor cost of moving and repairing this form was $1.82 per cubic yard. It is quite useless from the data available to attempt comparison of steel and wood forms. Though the examples cited show that wood forms have been most frequently used, this is, we think, a mere happening and signifies little. The steel form has peculiar merits for conduit construction and its consideration should never be neglected.

BATH, MAINE, ACQUIRES PROPERTIES OF MAINE WATER COMPANY AT LESS THAN REPRODUCTION COST.

The price to be paid by the city of Bath, Maine, to the Maine Water Company for the properties of the latter is less than the estimated reproduction cost of the plant. This has not happened before in New England. The price is $539,500, nearly $2,000 less than the reproduction cost, as determined by the joint conference of the engineers representing both sides.

This price was agreed upon by two engineers, Mr. Frederic H. Fay of Fay, Spofford & Thorndike, consulting engineers, Boston, Mass., and Mr. William B. Getchell of Augusta, Maine, selected as the two arbitrators by the Bath Water District and the Maine Water Company, respectively, with power to choose a third arbitrator in the event of a disagreement. These two engineers, however, came to an agreement without the necessity of calling in the third man. Both parties to the contract are satisfied and all litigation expenses have been avoided.

TABLE I.—RATIO OF SELLING PRICE TO REPRODUCTION COST OF WATER WORKS IN NEW ENGLAND.

Place.	Reproduction cost.	Price.	Ratio, price to reproduction cost.
Gardiner, Me.	$ 132,000	$ 245,000	1.85
Waterville, Me.	368,546	503,475	1.37
Augusta, Me.	287,279	427,135	1.48
Kittery, Me.	102,510	163,869	1.60
Livermore Falls, Me.	85,394	117,698	1.38
Portland, Me.	2,853,696	3,963,034	1.38
Gardner, Mass.	165,000	274,000	1.66
Athol, Mass.	206,386	316,500	1.53

The unusual feature of this transaction, aside from the businesslike manner in which it was conducted, is the relation of the price to the reproduction cost of the plant, as already pointed out. As will be noted in Table I, the usual purchase price for water systems throughout New England has been on the average one and a half times greater than the reproduction cost.

PREPARING TERRE HAUTE WATER CONSUMERS FOR THE INTRODUCTION OF WATER METERS.

The meterage system of selling water is to supplant the flat rate plan with about 2,250 customers of the Terre Haute Water Works Co. on April 1. Plans have been carefully laid to introduce these meters without antagonizing the customers of the company. This article tells what has been done along that line.

Circular Letter.—Under date of Feb. 16, 1916, Mr. Dow R. Gwinn, President and Manager of the company, sent a letter to all the customers who are to be changed over from flat to meter rates. The essentials paragraphs of that letter follow:

> Under its rules, this company reserves the right to change flat rate water supply service to metered service, at any time, by giving 30 days' notice in writing. This rule, among others, has been approved by the Public Service Commission of Indiana.
>
> Therefore, please take notice that, from and after April 1, 1916, your premises will be supplied on a meter basis. The meter will be set at the curb at the cost of this company.
>
> The Public Service Commission fixed the minimum monthly rate for small meters at 60 ct. and a rate of 20 ct. per 1,000 gal. for the first 20,000 gal. used per month; additional quantities at lower rates For the 60 ct. monthly minimum rate 3,000 gal. of water may be used.
>
> As we have over 2,200 meters to set before April 1, we are planning to start work in the near future. However, we will read the meter on April 1 and deduct whatever may be registered up to that date.

Questions Anticipated and Answered.—Enclosed with the foregoing letter was a circular containing questions and answers. The company tried to anticipate some of the questions that would naturally arise and endeavored to answer them in advance. That list of questions and answers follows:

> Question: Has the company a right to set a meter without the consumer's consent?
>
> Answer: Yes, the company has the legal right to supply any consumer by meter by giving 30 days' notice in writing. Furthermore, there is no method of charging that is as fair as the meter basis. No one would think of selling groceries, meat, drygoods, clothing or coal on a flat rate. It is a pretty good plan to pay for what you get. On this plan the careful man is not required to pay for the carelessness and willful waste of his neighbor.
>
> Why did you pick me out for a meter?
>
> The selection was not a personal one. The directors decided to meter every service where there are sprinkling connections, or where hose could be attached; also certain others where automobiles are washed; where there is stable use, boarders, roomers, etc. A total of over 5,800 meters will be in use. While the company has the right to set meters, any consumer may demand a meter.
>
> Can't you postpone the setting of a meter at my house until later?
>
> If we did it would materially interfere with the work. This is a matter which we have gone into very carefully and it has been thought best to go ahead with the work on account of the extra cost that would result if we did not complete the installation on each street before moving on to another. You will understand that as we have so many meters to set, we must do the work systematically.
>
> My bill is paid to April 1 and how can you set a meter before that time?
>
> The plan is to have the meter set now, but to begin the charge on the meter basis from April 1. On that day we will have the meters read so that whatever is registered up to that time can be deducted.

It is a good thing for the consumer to have the meter on for a while before the charge on that basis begins. If the reading before April 1 indicates a very heavy consumption of water, a search can be made for leaks. From the consumer's standpoint, it is desirable to get the leaks stopped before payment begins on the meter basis.

Why can't the meter be set in the basement? There is a place in the basement and I have my gas meter there?

We have had much trouble in getting readings of meters in basements; in some cases making a half dozen trips before being able to read the meter. Then some people object to having strange men enter their basements. Again, when the lady of the house is resting, it is very annoying to hear someone knocking at the back door and on going downstairs, find that a man wants to go down into the basement to read the meter. After going into the matter very carefully, we decided to place this lot of meters outdoors and made arrangements accordingly.

How about the sod if you set the meter on the grass plot?

In order to set the meter at the curb it is necessary to dig into the grass plot, but our men are instructed to replace the sod in a proper manner. We will endeavor to do this work to your satisfaction and if after they are all through, you should feel that the sod was not properly restored, we want you to let us know. It is our desire to please our patrons. You will understand that the earth will sometimes settle after it has been disturbed. Therefore, it may be necessary to send the men back again. We select men for this work who are usually careful, but if there should be evidence of carelessness at your place, we will consider it a favor if you will advise us.

Suppose I decide to have the water shut off?

We will be sorry to lose you as a customer, and may we suggest that you do not decide the matter today. Assuming that the bill is already paid up to April 1, you will have until then to look into the matter. Just let it stand at present and when April 1 arrives, you may conclude to stay with us. We will be glad to continue to serve you, and we are trying to make the service as near perfection as possible.

What assurance have consumers that water meters are accurate?

Consumers have a right to know whether the meters are accurate or not, and so the company has a standing offer to test meters in the presence of consumers (or their representatives) free of charge.

What has been the experience with meters on residences, and does the service cost more than on the flat rate?

Our records for the year 1913, when the summer was unusually dry and hot, show that we supplied 819 residences through meters. Of this number 89 per cent paid less than the flat rates and the total reduction in cost of water was 27 per cent. The average annual cost per consumer was $16.11 or 4.44 ct. per day. Bear in mind that the new rate for the first 20,000 gal. is 33⅓ per cent less than it was in 1913. You can see the above record if you desire.

If the meters on residences result in reducing the cost to the consumer, why does the company want to set 2,000 more meters?

The company must be in position to furnish water of a very high standard of purity under high pressure and in great quantities, in case of a serious fire. The average daily consumption in 1914 was about 5,000,000 gal., but at one time in the summer the peak of the load, or demand, was at the rate of over 16,000,000 gal. If a serious fire had occurred at that time it would have been impossible to have furnished satisfactory fire service. There is an ordinance providing a penalty for use of hose when there is a fire except as protection against fire. Unfortunately, many consumers on flat rates disregard this important ordinance; they turn on the hose and then forget about it. This does not seem to happen where there are meters.

Why doesn't the company put in more pumps?

The company now has a pumping capacity of about 20,000,000 gal., or say four times the ordinary daily pumpage. It was brought out in the sworn evidence before the Public Service Commission that if the sprinkling connections were not metered, it would be necessary to make additions to the plant in the way of pumps, filters, sedimentation reservoirs, buildings, etc., at an estimated cost of $125,000. And these would not be needed except in very dry weather, say for a few weeks in some summers and not at all in summers like the last one. Under the law the company would be entitled to earn interest and depreciation on account of this additional investment and the consumers would have to pay it. On the other hand, 2,000 to 2,500 ordinary meters could be installed for about $40,000. Any business man would not hesitate very long in deciding between these two plans when he realized that the use of meters would stop the waste.

Then this plan of setting meters is to enable the company to maintain proper fire pressure?

Yes, and also to enable it to keep the water up to the standard of purity, which is even more important than the fire service. Incidentally, Terre Haute enjoys the lowest insurance rates in the state. The U. S. Public Health Service has instituted most rigid requirements covering drinking water on trains operating in more than one state. The standard is very high; indeed, many think it is unnecessarily extreme. However, we are meeting with the requirements fixed by the U. S. officials and we feel that we must be in position to continue to do so. It is, therefore, absolutely necessary to be able to control the output of our plant. The officers of this company feel the responsibility resting upon them as purveyors of water to the community and they would not be doing their full duty if they failed to remedy any conditions that might jeopardize the purity of the water.

WINTER WORK IN THE CONSTRUCTION AND REPAIR OF DAMS AND SHORE PROTECTIONS IN THE UNITED STATES IMPROVEMENT OF THE UPPER MISSISSIPPI RIVER.

Contributed by C. W. Durham, Principal Assistant Engineer.

In northern latitudes, winter has been a slack season in engineering work of this kind, so that contractors and hired labor forces mark time during the cold weather months, men, capital and plant lying idle. But on the Mississippi River above Rock Island, Ill., it has been demonstrated that river improvement work of certain kinds can be done more cheaply during those months than in the period of open river and with almost equal rapidity. It is thought that advantage might be taken of this experience, in the improvement of other rivers, ice bound in winter, where the principle of channel improvement by contraction of waterway and protection of banks has also been adopted.

During the past five winters considerable construction and repair work has been done in January, February and March. At first the work was experimental, but the results after men had accustomed themselves to conditions, have proved economical, and now that several years have passed, are found to be durable.

Winter work was inaugurated in 1911 and carried on during that and the succeeding year partly by hired labor and partly by contract, but since 1912 solely by contract as being the most advantageous method.

TABLE I.—SUMMARY OF WINTER WORK, 1911-1915, INCLUSIVE.

Year.	Location and designation.	How and when performed.	Material (rock and brush), cubic yards.	Cost.	Average cost per cubic yard.
1911	Between Winona and Dubuque: Repaired 11 spur dams and 1 piece of shore protection; built 4 small closing dams......	Hired laher and contract—Jan. 2-Mar. 10.....	17,782	$17,155	$0.965
1912	Between Chimney Rock and Finley's Landing: Repaired 25 dams and 5 pieces of shore protection; completed 3 dams and built 3 dams........	Hired labor and contract—Jan. and Feb.......	43,016	36,396	.846
1913	Between Dresbach and Finley's Landing: Repaired 19 dams and 8 pieces of shore protection; built 8 dams......	Contract only—Jan. 2 to Mar. 7	49,933	44,444	.890
1914	Between Nininger and Bellevue: Repaired 51 dams; built 17 dams....	Contract—Jan. 5 to Mar. 9.....	117,565	103,984	.920
1915	Between Grey Cloud Landing and Montpelier: Repaired 42 dams, built 22 dams and extended 5...	Contract — Jan and Feb.......	111,789	99,533	

At several of the above named localities material was delivered at the rate of 180 to 200 team or sled loads daily.

The winter work of 1911, in which there is a great preponderance of rock, the more expensive material, compares favorably with other work of the year done during the season of navigation, if the relative quantities of rock and brush are considered and in fact shows a saving of 6 to 10 ct. per yard over some contract work in which brush was in excess.

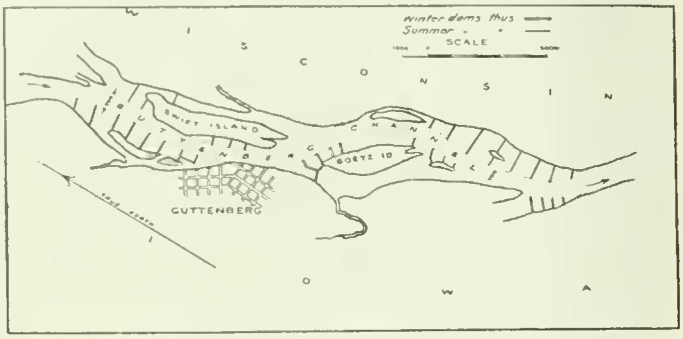
In 1912, when the work was similar in proportions of material, winter work shows a saving of 18.7 to 23.8 ct. per yard over hired labor and contract work respectively, performed during open river, or from $8,043 to $10,237.

In 1913, the winter work which was performed entirely by contract, was very economical, the saving as compared with similar work done in open river being from 13 to 19 ct. per yard, and amounting to about $8,225.

In 1914, the winter work also performed entirely by contract, was about 7 ct. per yard cheaper than the open-river work of 1913 done under similar proportions of rock and brush, both by hired labor and contract. There is an indicated saving of about $9,400.

Table II enumerates the work of 1915 in more detail.

A comparison of cost is made with the open-river work of 1913 hired-labor and contract. This was a normal year relative proportion of rock being considered, whereas the seasons of 1914 and 1915 were very short, operations being curtailed by lack of funds and high water and the cost per unit was much greater than usual.



Sketch Map of Guttenberg Channel Showing Winter Dams Built 1911-15.

In division No. 1 at Grey Cloud, 15,622 cu. yd. of material was put in place at $0.867 per yard, a saving of approximately .226 per yard or $3,531.

In division No. 2 at various points, 34,911 cu. yd. of material was put in place at $1.004 per yard, a saving of .059 per yard or $2,060.

In division No. 3 at a number of localities, 55,384 cu. yd. of material was used at .812 per yard, a saving of .146 per yard or $8,086.

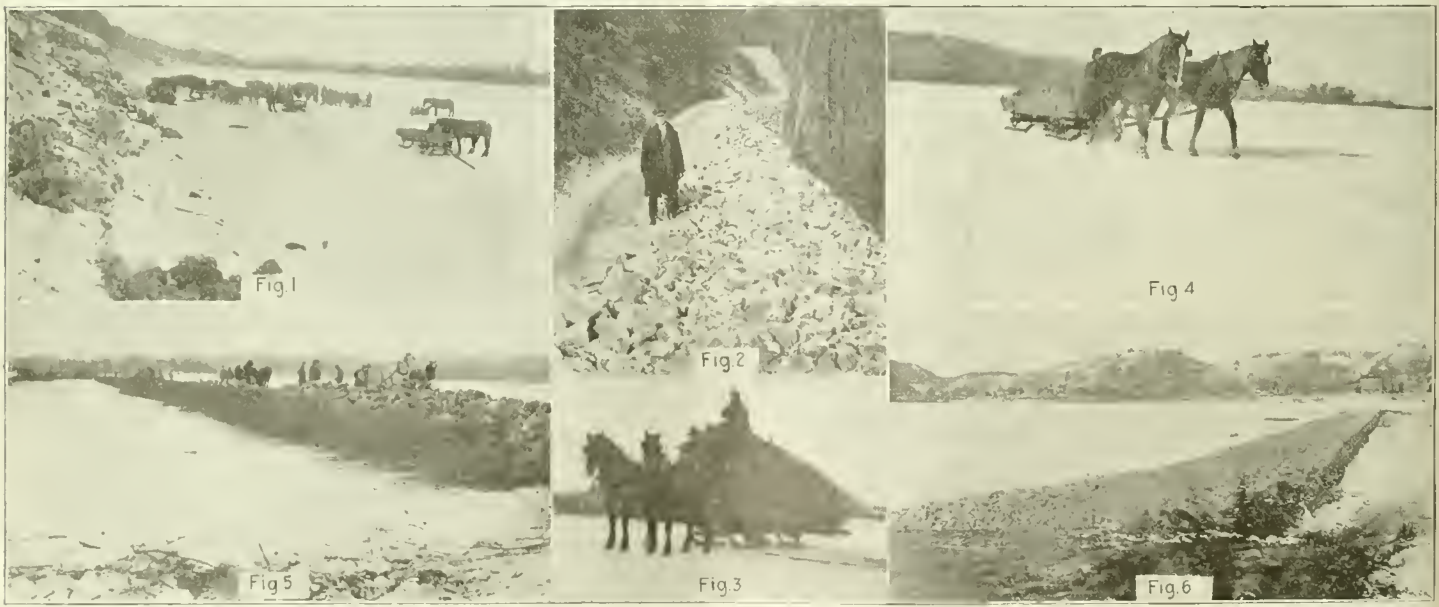
In division No. 5, in vicinity of Montpelier, 5,871 cu. yd. were placed at a cost of $1.03, indicating neither saving nor loss. This locality is too far south for effective and economical winter work.

Total approximate saving for the district $13,677.

To insure the complete success of winter work as regards economy and rate of progress, a cold winter is needed in order that ice may form of sufficient strength to sustain the weight of sleds loaded with brush and rock to be hauled to the desired locality. It is noted, however, that even in very cold weather air holes and weak ice often compel long detours.

Only that portion of the Upper Mississippi above Rock Island, which is 361 miles below St. Paul, is reliable for winter work, as below that point winters are shorter and of less severity as regards temperature. No floating plant or machinery is required and the great cost of steamboats, barges, quarterboats, etc., used in open-river work, and of their operation and maintenance is eliminated. In addition to the contractor's own teams, which would otherwise be idle, teams belonging to neighboring farmers and others are hired at a time when they are not much needed for work; labor is usually plentiful and men can be fully employed, either in getting out material or placing it in the work,—in fact conditions in most respects are very favorable for economical work and especially so as regards labor problems.

For winter work are selected dams to be built in shallow water, across bars or in chutes not accessible at low stages to boats and barges, and the material, especially rock, is mostly obtained from localities near at hand and perhaps inaccessible at any time to floating plant. In repairing dams and shore protections, and in building the latter, the depth of water is immaterial. There are large quantities of loose rock in the ravines of the adjacent bluffs which can be gathered and loaded on sleds or wagons very cheaply, but which could not be reached by barges on which to load it. Considerable rock is thus obtained for winter work without the expense of quarrying and the difficulties of obtaining and delivering brush are often much lessened. It is preferable to get the rock gathered up and ready for loading in the fall, and if any bank is to be graded for shore protection, it is done before the ground freezes. It has been found most advantageous to have the entire work done by contract, or agreement, as contractors are in better condition to keep their men fully employed, both in getting out material and in placing it, which the Government can not always do when it purchases the material on sleds or wagons at the site of the work and puts it in place by hired labor. A shortage of material, as frequently happens, keeps men, under these circumstances, partially unemployed. It has been demonstrated that contractors can make a good profit and at the same time perform the work at lower cost than the Government, which is more hampered by the 8-hour laws.



VIEWS OF WINTER DAM BUILDING ON THE UPPER MISSISSIPPI IMPROVEMENT.
Fig. 1.—Outfit During Noonhour Rest. Fig. 2.—Stone Stored In Gulleys for Winter Hauling. Fig. 3.—Hauling Brush for Wing Dam Construction. Fig. 4.—Hauling Stone for Wing Dam Construction. Figs. 5 and 6.—Completed Wing Dam.

The specifications for rock and brush are the same as those used in hired labor and contract work during the open river season. "Brush which must be alive when cut, is made into bundles 20 ft. long and from 9 to 12 in. in diameter, sufficiently trimmed and choked to form a compact mass and tied with four bands of lath yarn of not more than 120 strands, or with wire not smaller than No. 18; approximately 3½ in. in diameter at the butts and 1½ in. at small ends. When made into mats the fascines or bundles of brush shall be closely packed and secured by at least three pairs of binding poles, if required, joined by ties of Itah yarn or wire about 2 ft. apart."

The brush is delivered to the work on sleds or in piles

TABLE II.—WINTER WORK, 1915.

Location and designation.	Work began and ended.	Material—Rock. Cu. yd.	Material—Brush. Cu. yd.	Material—Total. Cu. yd.	Cost, including inspection.	Average cost per cubic yard including inspection.
In vicinity of Grey Cloud Landing, Minn., 4 dams were built and 13 repaired	January and February, 1915. Contract prices for material in place: Rock, $1.25; brush, 47 ct. per cubic yard	7,381.6	8,240.9	15,622.5	$13,550.22	$0.867
In vicinities of Trempeleau, La Plume Island, Root River, Swift Slough and Genoa 1 dam was built, 3 extended and 1 repaired	January and February, 1915. Contract prices for material in place: Rock, $1.38 to $1.69; brush, 37½ to 42 ct. per cubic yard	16,040.3	18,871.5	34,911.8	35,039.74	1.004
In vicinities of Guttenberg, Cassville, Waupeton, Eagle Point and Bellevue 17 dams were built, 2 extended and 9 repaired	January and February, 1915. Contract prices for material in place: Rock, $1.43 to $1.50; brush, 44 to 53 ct. per cubic yard	17,116.5	38,267.4	55,383.9	44,953.71	.812
In vicinity of Montpelier 4 dams were repaired	January and February, 1915. Contract prices for material in place: Rock, $1.52; brush, 62 ct. per cubic yard	2,254.6	3,616.3	5,870.9	5,989.10	1.020
Total		47,793.0	68,996.1	111,789.1	$99,532.77	$0.890

on the ice. It is placed as in summer work, either by building mats, or with loose bundles where the water is very shoal. Skids are used in launching the mats for dam and shore protection repairs.

"Rock must be hard, durable, and of a kind that will not disintegrate on exposure to the action of the water or atmosphere and in pieces weighing 5 to 100 lb." The rock is brought to the work on sleds or wagons and unloaded directly on the dam or shore protection. It is measured by the load and, as all racks on each job are made to uniform length and width, it is only necessary to measure the height of each load.

In making repairs of shore protections or in building them, the ice is cut away as the work progresses. In the case of dam repairs, the ice is cut or sawed along the line of dam and below it for a width of 20 to 30 ft., and then sunk or removed to a distance, so that there will be no unnecessary weight near the opening. All new dams are built in the manner as below described. Beginning at the shore end two sets of binding poles about 10 ft. apart are laid on the ice and securely tied into one continuous pole with wire or lath yarn. Brush is then laid on exactly as in summer work, making a mat 2 or 3 bundles thick, or as desired. Poles are then laid on top, tied together and to the lower poles at the proper intervals. After about 200 lin. ft. of mat has been built and securely tied, the ice is cut with a saw close to both butts and tips (the latter being always on the upstream side) from shore out to a point about 30 ft. from end of mat. Rock is then thrown on the mat and the mat is sunk, except that the outer 30 ft. remains on the uncut ice. The mat is continued without breaking from there on to outer end of dam in the same manner. Returning to the shore end, the same process is repeated until the dam is brought to grade. No apron mat is used and the lower side of the dam is vertical.

Estimated operating cost of work done by contract in vicinity of Guttenberg, Iowa, January and February, 1915.

Rock: 887 cu. yd., quarried, loaded and hauled on sleds to dam at 50 ct		$ 443.50
Rock: 4,631.9 cu. yd., gathered in ravines and delivered at dam at 26 ct		1,204.29
Brush: 10,583.7 cu. yd., made into bundles and delivered at dam at 25 ct		2,645.93
Cost of material		$4,293.72
Labor:		
1 foreman 1 month	$ 125.00	
1 foreman 1 month	80.00	
1 timekeeper 1 month	50.00	
24 laborers 720 days at $2	1,440.00	
13 teams and teamsters 390 days at $4	1,560.00	3,255.00
Repairs to sleds, tools, etc		100.00
Miscellaneous expenses, estimated 20 per cent		1,529.94
Total cost to contractor		$9,178.66
Amount paid by government		13,781.87
Contractor's profit		$4,603.21

This profit is exceptionally large on account of the unusually great quantity of "pick-up" rock.

A contract was let in Nov., 1915, for improvement work at Wyalusing, Wis., involving the placing of 3,700 cu. yd. rock and 9,700 cu. yd. brush in wing dams, the prices being $1.18 for rock and 38 ct. for brush, which are much lower than in recent years and which show a very large saving to the Government over open-river work.

THE DUTY OF THE IRRIGATION ENGINEER.*

By L. M. Rice, Civil Engineer.

The mere planning and building the head gates, canals, ditches and flumes of an irrigation plant, is not all the duties that should be performed by the engineer. No plant is properly planned that does not provide ways by means of which the capital invested receives a fair rate of interest, and that from the output of the plant. He should go beyond the mere building of structures through which water is transmitted. He must look to the foundation upon which the whole structure is builded. He must study and understand every problem connected with the carrying of an irrigation problem to a successful conclusion. The problems of construction are not solved until such time as he is able to lay the foundation upon which to build a paying institution. In order to do this, he must understand the human problem involved. No one is in a better position to study these problems than the engineer. It is therefore, up to him to see that the man on the land is firmly rooted to the soil.

The engineer should see that every detail of construction has been carried out, that there is nothing left in the shape of construction work for the man on the land to do. In making his estimate he should not only estimate the cost of the main canals and main laterals, but he should estimate the cost of all laterals that are necessary for the development of each piece of land, as well as the cost necessary for the leveling of these lands so that they may be irrigated. The clearing of the lands on an irrigation project, removing the stones and the leveling of the same, in order that water may be placed upon it, is just as much construction work as the building of the head works, and no project is complete until such time as the man upon the land is able to produce crops, and through the sale of same, is able to live and pay the necessary charge levied against him. Nothing should be left to him other than work incidental to farm operation. All other costs should be included in the bond issue and should be carried as a construction charge the same as any other portion of the work.

DECISION OF THE CHIEF OF ENGINEERS, U. S. A., AGAINST THE ILLINOIS WATERWAY.†

This waterway is a route, partly natural and partly artificial, from the navigable portion of the Chicago drainage canal to the improved portion of the Illinois river, which thus forms a link between the waterways of the great lakes and the waterways of the Mississippi river systems. This is proposed to be developed to a ruling depth of eight feet. Improvement is to be effected by locks and dams and by channel excavation where necessary. In connection with the dams a large water power is to be developed, possibly as great as 80,000 horsepower.

The state of Illinois proposes to execute these works of improvement and to retain for itself in perpetuity all rights to the water power development, and to collect in the form of tolls from these utilities, that is to say, from navigation and water power, a sum sufficient to pay the interest on all the bonds which it may be necessary to issue for the improvement and to provide a sinking fund to pay the bonds themselves in twenty years and to provide all money necessary for operating and caring for these works.

---

*Extract from an address before the Oregon Irrigation Congress, Dec. 29, 1915.

†Memorandum by Gen. Dan. C. Kingman, Chief of Engineers, U. S. A., for the Secretary of War.

After the state is completely reimbursed for its expenditures, it proposes to offer the navigation facilities to the United States as a gift, subject to the condition that the United States shall operate and care for them ever afterwards without any tax or tolls whatever.

That this is a good proposition for the state of Illinois I think there is no doubt. That it is an engineering possibility I think there is also no doubt. But I do not think it is the best engineering solution of the problem that sufficient study could devise, although I think it would be admissible if any one chose to adopt it, were it not for certain conditions which render its enforcement uncertain and its results unfair and inequitable.

It would be a very simple matter if this waterway in question were a stream lying wholly in the state of Illinois, its source and its mouth being both in that state and the public rights on the river being no greater for the citizens of that state than for those of any other.

But this is very far from being the case. There now exists a waterway, partly natural and partly artificial or artificially improved, from the city of New York at the mouth of the Hudson river, via this river and the canal built by the state of New York, thence via the great lakes to Chicago, passing through the connecting waters and harbors improved at the cost of the United States, thence to Lockport over waters improved by the state of Illinois, thence partly by canal and partly by improved waterway to be built by the state of Illinois through the improved portion of the Illinois river below, and finally by the Illinois river, improved in part by the United States, to the Mississippi, and thence to the sea by the navigable waters which connect with this river and form this system.

The state of New York has already expended more than $100,000,000 in the last enlargement of the Erie canal. The United States has spent enormous sums on the Hudson river improvements, the great lakes improvements, the Illinois river improvements, and the Mississippi river system of improvements.

The value and importance of a short waterway connecting very extensive ones cannot be measured by its length alone.

Freight can be carried by water under favorable conditions for one-tenth of a cent per ton mile, or for 6.2 cents for the entire length of the route, but I think it evident that a very much higher rate than this would be charged by the power which controlled this waterway.

All of the rivers and waterways of the United States that have been improved by the general government have been made absolutely free of tolls, and the same has been done by the state of New York with its magnificent system of canals. Articles of commerce originating along this Illinois waterway when they leave it can pass without tolls through all the improved sections of water, including the canals of New York, until it reaches the sea. And everything which originates from the sea to Chicago will pass without charge until it reaches this little section and then will be compelled to deliver to the toll gatherer its percentage of tax.

It is true tolls are now charged by the state of Illinois on the upper portion of the Illinois river, which is at present maintained by said state, but on no other part of the entire route is any toll charged.

I do not think it good engineering to tax in this peculiar and very exceptional way one little section of a long inland route. I do not think that owing to this very peculiar and exceptional condition any executive branch of the government should undertake to permit this unusual thing to be done without special instruction from congress.

With the exception of the state of New York, none of the states, I think, have successfully maintained and developed their canals. The government has given up a good deal of public land at one time or another, with a view to securing improvement in navigation.

ORGANIZATION AS INFLUENCED BY PHYSICAL CONDITIONS OF CONCRETING GANGS FOR ROAD CONSTRUCTION.*

By Wm. F. McVaugh.

There are five points which are worthy of investigation by any contractor before he decides definitely on just how much work he can count with a mixing crew of given size, and unless due consideration is shown them and their importance is appreciated, the contractor is liable to find that his crew is not coming up to expectations. These considerations bear largely on the amount of work that a crew can do rather than figure in determining the number of men in a crew.

It is the purpose of this report to treat with the subject of mixing crews from the practical standpoint, and conclusions that will be drawn are based on figures that came from contractors who have constructed considerable yardages of concrete road and pavement. A wide variation will be noticed in some of the figures quoted, but as the experience of the contractors varies this is not to be wondered at.

Investigation of this subject shows that the following conditions, ranged in order of their importance, are the factors that are worthy of investigation before the crew is finally organized, and a thorough knowledge of them will assist a contractor in determining the amount of work a given number of men in a mixing crew can be expected to turn out on any particular job. (1) Placing of Materials; (2) Experience of Men; (3) Width of Streets; (4) Obstruction (Car tracks); (5) Character of Subgrade.

(1) Placing of Materials.—The proper placing of sand, gravel and cement is one of the first considerations in the economical construction of a concrete road. The success of the work depends very largely on the time consumed in loading the mixer, and the number of square yards that a mixing crew of any size is capable of laying varies inversely as the distance of the materials from the mixer. It is of course possible, and many times it is the practice, to so distribute the sand and gravel as to have them too near to the mixer the greater part of the time. This leads to confusion at the hopper as sufficient room for the men to pass with loaded and empty wheelbarrows must be provided. The question as to just how far to have the materials from the hopper is determined by the distance the mixer is to be moved each time. If the material piles are too big every move of the mixer brings it onto the pile and if the reverse is the case the haul becomes excessive, and snatch teams must necessarily be resorted to to redistribute the material. All such extra work can be avoided if the contractor spends a little time in figuring on this important question.

The cement piles should also be distributed with as great care as should be used in placing the sand and gravel, for the untying and shaking of the sack requires considerable time and unless this operation is speedily accomplished the entire mixing crew is held up.

(2) Experience of Men.—It is often found advisable to use a few extra men on the aggregates at the beginning of a job if the crew is inexperienced. These extra men are usually used as shovelers to load the wheelbarrows for the wheelers, because of their inexperience, use considerable time in dumping the barrows into the mixer hopper and in making trip. By having the extra shovelers the time of the loading is cut down and this delay is avoided.

Some contractors so arrange their crews as to have the men handling the sand and gravel do their own loading, while others have two sets of men on the aggregates, wheelers and shovelers. The wheelers handle the barrows and dump them into the mixer hopper, while the shovelers' duties are to load the barrows for the wheelers. On most jobs the positions are interchangeable to give the wheelers rest.

The contractors who use the shovelers and wheelers are strongly of the opinion that it is a great saving over the system of having each man do his own loading and wheeling, and that in a well organized crew the shovelers are kept busy scraping the aggregates into piles convenient for shoveling; consequently the scattering of the sand and gravel over the subgrade is eliminated to a great extent.

---

*Prepared as part of report of Special Committee of the National Conference on Concrete Road Building.

(3) **Width of Street.**—With the proper placing of material, etc., a crew of given size can lay a greater number of square yards of pavement in a day on a wide street than on a narrow street. This holds true with noticeable consistency with each contractor.

The yardage on streets of different widths plotted graphically, using the width of street for the abscissas and square yards for the ordinates for the year's work of one contractor, showed an increase from a 13-ft. street up to a 30-ft. street, and the increment of increased yardage varied with the increased width of street. On a 13-ft. street the average daily yardage was 600 sq. yd.; a 24-ft. street, 750 sq. yd.; a 25-ft. street, 850 sq. yd.; a 27-ft. street, 917 sq. yd.; and a 30-ft. street, approximately 950 sq. yd.

The information secured from contractors all followed about the same proportionate increase for different width of streets, although nearly all of them did not decrease the number of men in their mixing crews for the narrower street, consequently the charge for mixing has remained a constant factor, which of course raises the labor charges per square yard for the narrower street.

None of those contractors consulted were inclined to be of the opinion that it would be advisable to decrease in any way the number of men used for handling the aggregates on the narrower widths of street, even in spite of the fact that the daily yardage was decreased considerably. Further, many of them stated that while they had no exact figures in regard to this matter, they could recall having experimented with the smaller size crews and in every instance decided that it was more economical to retain the same size crew, regardless of width of street.

(4) **Obstruction.**—When work is being done on streets with car tracks it is often found that the labor charges per square yard of pavement are higher than on other streets, due largely to the fact that the passing car interferes to some extent with the workmen. It has been the experience of one contractor, well established in the concrete road building business, that when concreting is done on a street with a railway down the center, the crew, which on a 25-ft. street would average 850 sq. yd. a day, could do no better than an average of 600 sq. yd. a day. In this particular case the pavement was 13 ft. wide on either side of the track and as a consequence there was insufficient room to allow the crew to work to advantage, as the sand and gravel had necessarily to be placed too close to each other, and it was found that the passing cars disorganized the crew to a considerable extent.

(5) **Character of Subgrade.**—The character of the subgrade determines whether or not planks will have to be used on which to wheel the wheelbarrows and in cases where the subgrade is especially soft it is found that the progress of the crew is retarded considerably, but we know of no way whereby this would influence the size of the mixing crew, for additional men would not help matters materially, except, perhaps, to have one man line up the wheeling planks.

Conclusions.—The foregoing considerations which have been enumerated, while they figure conspicuously in determining the number of square yards of road or pavement that a mixing crew of given size is capable of turning out daily, yet we cannot see wherein they would, to any appreciable extent, enter into consideration in determining the size of the mixing crew. There are really only two considerations which are of paramount importance in determining the number of men in any crew.

(1) The size of the mixer batch to be used, that is, whether it is a one, two, or three sack batch.

(2) The placing of the aggregates. This second consideration, however, is one that can be, with a little study, eliminated entirely from any job, for with the proper placing of the aggregates no additional men are needed to assist in the long haul.

In conclusion we would say that for the average job it would be a fair rule to follow, to use one shoveler for each wheeler, the number of wheelers being determined by the size of the batch, and in no case should a man be required to wheel more than 2½ cu. ft. of sand or gravel. The number of men on the cement would be two for a two-sack batch and the same number for a three-sack batch. When a three-sack batch is used the men could alternate in making the extra trip.

The crew that can be most economically worked under average conditions should be made up as follows:

Using two-sack batch—Mixture 1-2-3: Cement, two men from piles; Sand, two wheelers, two shovelers; Gravel, three wheelers, three shovelers; Helper, one at mixer hopper.

Three-sack batch—Mixture 1-2-3: Cement, two men from piles (alternate); Sand, three shovelers, three wheelers; Gravel, four shovelers, four wheelers; Helper, one at mixer hopper.

The shovelers may be cut down to two on gravel when the street is narrow, but under ordinary conditions it will be found better to have a separate wheeler and shoveler for each wheelbarrow. The helper at the hopper is not a common hand on the average crew, but we believe he can be used to an advantage in helping keep the wheeling planks in line, if planks are used, and in assisting the wheelers in dumping the barrows so that the materials are thrown well back into the hopper.

CODE OF ETHICS FOR THE WESTERN SOCIETY OF ENGINEERS.*

The following code of ethics is intended to cover only the general duties and obligations of the engineer, and is not to be regarded as an attempt to enter into specific directions.

I. A profession is a vocation in life requiring specialized intellectual attainment, which can be usefully devoted to the services of others.

II. The opportunity to serve human society with specialized skill is not confined to the professions, but professional service is peculiar in that it is the product of mental inquiry and analysis upon problems which cannot be properly solved by purely mechanical skill or training.

III. Competent professional service therefore, whether for the community, the corporation or the individual, requires a certain liberty of thought and action with some freedom from undue direction which is not so noticeable in other callings. This larger requirement, as a trust, carries with it the responsibility of producing the most effective results consistent with all the limiting circumstances.

IV. It follows that a capable professional man should be necessarily and peculiarly the repository of confidence and trust on the part of those whom he well serves, and such necessary confidence and trust should in turn inspire in him as an obligation, the highest sentiments of honor and good faith.

V. The first and highest aim of a professional man should be to render the most effective and efficient service consistent with the opportunities afforded him. Questions of his remuneration cannot properly take precedence of the quality of his service, but must be of secondary importance. It is, however, a secondary duty to see that his services are properly understood, appreciated and sufficiently rewarded by adequate compensation, not only in justice to himself and his family, but as a mark of respect to his profession.

VI. The adjustment of proper relations between professional men, particularly among those in the same profession, is a very important factor in the public respect and confidence accorded their calling, as well as the usefulness and efficiency of their individual service.

Success in both of these directions is largely determined by the completeness with which each member realizes the fraternal idea; and as a result,

---

*Code recommended by a special committee composed of Hiero B. Herr, John W. Alvord, C. R. Dart, P. Junkersfield and C. F. Loweth.

(1) makes appropriation from the joint inheritance of common professional knowledge;

(2) receives especial aid tendered by his professional brethren,

(3) and as well, gives to the profession in return unselfish and cordial allegiance in all matters.

VII. The enginer is always deeply indebted to his profession in some or all of the following ways:

(a) For the use of the great body of common knowledge of the art freely and laboriously placed on record for his benefit by the pioneers who have gone before him.

(b) By the gratuitous labor of his cotemporaries in promptly offering him in print the result of their experience in both practice and theory.

(c) By the personal help and suggestion he receives (when in good standing) from his cotemporaries in difficult situations of urgency.

(d) For the colleges and libraries which have been created for his instruction, use and benefit by the state and by private liberality.

(e) For the technical societies that afford him opportunity to interchange ideas, and print for the common benefit, opinions, experience and studies in the engineering and useful arts.

(f) For the advantageous position in which he finds himself as a member of a trusted calling, due to the honorable lives and upright characters of those who have preceded him or who lead at the present time.

(g) For the spirit of fraternity and co-operation which he may enjoy from the members of his profession when he has shown himself, in spirit as well as in the letter, worthy of their professional confidence.

(h) For the further opportunity to enjoy that peculiar esteem and consideration from the laymen of his time which is generously accorded to those who have found respect and merit within the profession itself.

VIII. The recipient of all these opportunities can show his appreciation for these privileges in some degree by the following return:

(a) He can lead an honorable and upright life.

(b) He can regard the profession as a fraternity and act on this theory.

(c) He can lose no opportunity to improve his professional information to the end of bettering his service to his employer or his client.

(d) He can uphold the dignity of his profession by cheerfully giving credit to his cotemporaries for their good work and avoiding all envy or petty jealousy.

(e) He can do his share in supporting societies created for professional benefit and contributing when possible to their store of useful knowledge.

(f) When needfully confronted with the necessity of honorable competition with professional brethren, it should be entered into with the utmost courtesy and consideration for all concerned, and to say the least, without public exhibition of greed, self-laudation, jealousy or ill humor. Some degree of honorable and courteous competition among professional men is often inevitable, particularly for salaried positions, and at times in all except the higher class of consulting work. This being so, the courtesies and ethics of competition should be studied and cultivated with especial care to the end that the fraternal feeling in the profession does not suffer. Competition in professional work where it enters in at all, should always be on the basis of efficiency in service offered, and never knowingly, in price concessions.

(g) The engineer should always assure himself, as far as possible, that the professional services he renders are in value reasonably in excess of the salary received or fee charged. Where he is in position to fix his own fee, the utmost conscientiousness about charges is to be observed.

(h) He can be a "gentleman" always and everywhere. He can follow the "Golden Rule."

Engineering is a useful art. Its purpose is to constantly promote a higher civilization for mankind by discovering and creating improvements that are in harmony with natural laws.

The engineer, while at times a scientific discoverer, is more commonly a student and interpreter of science. His chief function is to reduce scientific discovery to practical, useful and economic forms for the safety, comfort and convenience of mankind.

Pure science concerns itself with the discovery of the laws of nature. The engineer ordinarily adapts the discovered laws of nature to the use of man.

While engineering in its elementary operations utilizes mechanical and mathematical methods of expression, which at times gives such work an undue appearance of exactness, these aids properly understood, are, nevertheless, entirely tools subordinate to the chief function of the engineering mind which is essentially judicial and reasoning in character.

The engineer properly analyzing his problem, secures and arrays the facts and develops the evidence affecting the result in each case, tests them in the light of reason and natural law, and judicially determines from the record before him, the proper economic procedure. In all his work to some extent, and in his highest responsibility to a very large extent, he is the final judge who is versed in the science of applying economic truth and natural law, so as to conserve mankind.

Engineering, therefore, being a vocation in life requiring specialized intellectual attainment in the domain of judicial, economic and scientific inquiry and practice, is a profession, and is subject to all the opportunities and restrictions heretofore recited and commonly found to be needful to professional life.

IX. The engineering profession has public duties. In a sense the engineer is in part a public servant. Engineering education is fostered by public and privately endowed institutions, it is aided by the state and national government by special investigations and publications. This is because the state and the public are keenly alive to the public character of the engineering profession's responsibilities. The life, safety, health, comfort and convenience of the public is dependent upon the work of the engineer.

In return then, the engineer has public responsibilities to meet and public duties to perform. These are chiefly as follows:

(a) In all engineering problems the public safety ranks first and is above all other considerations.

(b) In the development of the art of engineering, it is incumbent upon the engineer to educate the public up to a right perception and appreciation of engineering problems.

(c) The engineer should always stand ready to voice publicly, safety and security and sound economics in the public administration of engineering.

(d) Service to the public, directly or indirectly is the appropriate and natural opportunity of the engineer, and that it is even less well paid than private service is, perhaps, in part due to the fact that the engineering profession is indebted to the public primarily. Public service, is, therefore, a peculiarly honorable service and should be especially respected.

(e) General engineering advice may in certain emergencies, and with reason and caution be appropriately tendered to the public without charge, but not to the prejudice of careful investigations where necessary or to the discouragement of inquiry requiring ample funds, or to the cheapening or discrediting of the public problem in hand.

To recapitulate, the ethical standards of the enginering profession should be those of a fraternity. The engineer should recognize that he is endowed by the profession and the state with specialized knowledge for peculiar, judicial and responsible public service involving the life, safety, comfort and convenience of his own and coming generations, and that in response to these he should so conduct himself as to be appreciative of his indebtedness to his profession for his opportunity, and make return by every effort by a life of special usefulness devoid of unseemly greed, and filled, if possible, with a multitude of these small coutesies, the practice of which encourages the spirit of forebearance and is helpfully conducive to the fine art of living well together.

NEW CEMENT PLANT FOR SERVICE OF THE NORTHWESTERN STATES.

The Duluth plant of the Universal Portland Cement Co. is in operation. It is known as Mill No. 7, and has a daily capacity of 4,000 barrels. As in the case of other Universal mills, blast furnace slag is used in the manufacture of the cement. The plant adjoins that of the Minnesota Steel Co., from which the slag is secured. The limestone comes from Calcite, Mich. The mill is operated by power furnished by the Great Northern Power Co. from its hydro-electric plant at Thompson, Minn., on the St. Louis River, fifteen miles distant. Four thousand K.W. at a voltage of 66,000 comes into the plant over a transmission line. The power company has a transformer station at the plant where the voltage is stepped down to 2,200. The Universal Portland Cement Co. has its own transforming station which steps about half of the current down to 220 volts, the other half being used direct at the 2,200 voltage.

All the grinding, burning and finishing machinery is operated on the individual motor system, and the same processes of manufacture are used as in the other mills of the company.

The plant is built of concrete and steel, the 17 buildings being constructed of monolithic, reinforced concrete, or of steel frames with concrete blocks. The floors and roofs are also of concrete. The storage tanks, 27 in number, are of circular concrete design. The plant employs between 300 and 400 men, for whose accommodation an industrial town has been constructed near the plant. The town is called Morgan Park, and will house the employes of the Minnesota Steel Co. as well. All the houses, streets, alleys, curbs and sidewalks in this town are of concrete construction. There are approximately 450 residence buildings, including apartment houses and single dwellings, but by a diversity of architecture there is no suggestion of the uniformity of construction usually prevailing in industrial towns.

This plant is designed to furnish prompt service for the rapidly increasing demand for cement in the Northwest. This section has hitherto been supplied from mills in Iowa, Illinois, Indiana and Michigan.

EFFECT OF ALKALI ON CONCRETE.

The engineers of the U. S. Reclamation Service have undertaken an investigation to determine the effect of alkali waters and soils on concrete. Some preliminary conclusions of this investigation are given in the February issue of the Reclamation Record, from which the following is taken:

The principal salts acting to produce disintegration are the sulphates, especially magnesium and sodium sulphates. It is thought that of these the former is the more active, but this has not been definitely established. Different localities have shown different results for the same materials.

Two extreme cases may be cited in the Sunnyside and Belle Fourche projects. Of a number of test specimens exposed on the former no disintegration was observed at the end of about eleven months, with the exception of a specimen containing a soap and alum solution in the mix. The specimens were all of a 1:3:5 gravel mixture. Furthermore, none of the concrete structures on this project have been affected. On the other hand, various mixtures exposed on the Belle Fourche project were all found to be disintegrated at the end of eight months, with the exception of a 1:2 mortar specimen which was not affected. Concrete structures on this project have also been disintegrated by alkali. Other projects showed intermediate results.

Analyses of samples from the Belle Fourche project show magnesium and sodium sulphates present in strong solution, with the former predominating, and samples from the Sunnyside project show sodium sulphate only, and in much lighter solution. As a general proposition, it must for the present be concluded that in locations where alkali containing these salts is present, special precautions must be taken to prevent its possible action, unless experience with structures previously built has shown no deleterious effect, as in the case of the Sunnyside project above cited.

It has been quite clearly demonstrated that the leaner mixtures of concrete are more easily disintegrated than the richer; also, that the more scientifically proportioned mixtures—that is, those having least voids for given proportions of cement and aggregate—give better results. This is a natural result, as the action results from seepage of water into or through the concrete, which is retarded by the richer and more scientifically proportioned concrete.

Experiments have shown that the more nearly impervious the concrete the less it is disintegrated by alkali. It is a natural deduction, therefore, that waterproof concrete will resist alkali action. Such concrete, under certain conditions, may be difficult to produce. Laboratory experiments have shown that it is possible to produce concrete that is practically impervious to water up to 50 to 75 lb. per square inch pressure, and satisfactory results have been obtained in the production of an impervious concrete in the field, on structures where special care was taken toward that end.

There are numerous patented waterproofing compounds on the market; there are also being manufactured several so-called alkali-proof cements. A number of these have been tested, but the results have not been any better than those obtained with straight Portland cement. Sand cements also have so far shown no superior alkali-resisting qualities. J. Y. Jewett, cement expert, gives his tentative opinion "that with good cement, with care in the selection of suitable aggregates, with proportioning to produce a rich dense mixture, and with proper methods of mixing and placing, it is possible to produce a dense, impervious concrete that will withstand the alkali action under ordinary conditions without the use of any special materials for waterproofing purposes." With fairly rich concrete an impervious skin of neat cement or rich mortar, such as is produced by working a flat spade between the concrete and steel or surfaced wood forms, will no doubt also have a decided effect in resisting the action of alkali.

THE DESIGN AND CONSTRUCTION OF FORMS FOR CONCRETE WORK.*

By R. A. Sherwin, Aberthaw Construction Co., Boston, Mass.

III.

[Part I, covering the general principles of form design, and Part II, discussing and giving specific data on the size and spacing of members and on drafting room methods, were published in our issues of March 1 and March 15, respectively.—Editors.]

Materials.

Schedule.—The materials to be used for the form work should be scheduled from the form drawings and not ordered by guess, as is so generally the custom. If complete form drawings for the job are available in time it is economical to order even the boards for column and beam forms to exact widths and lengths to make up the panels. This saves ripping and cutting off the boards in the job mill where the saws are often taxed beyond their capacity at the beginning of the job getting out miscellaneous work.

It is always desirable to get the lumber in carload lots because of the lower price. For this reason on many jobs, in order to get the stock in time from the mill-shipment, it is necessary to prepare the schedule from the general assembly and typical details.

The joists, girts, posts, braces, and sills can be taken from the general assembly plan directly by multiplying the stock required for a typical day by the number of bays in the building and the number of floors of centering needed. Girts and joists should be ordered edged to obtain an even bearing for these members.

The board feet of ⅞-in. roofers for slab and wall panels can be taken off directly from the square feet of floors and wall surface, adding at least 10 per cent for waste and 25 per cent for cleats. As these come in random lengths it is desirable to specify the length preferred so as to get as big a percentage of this length as possible.

One and one-half-inch boards for column and beam sides and 2-in. plank for beam bottoms should be ordered P-4-S. Boards 7¾-in. and 5¾-in. wide after planing are the most useful widths for beam and column sides and can be ordered in random lengths, specifying again the lengths desired for as a big a percentage as possible. The best length for the majority of columns and beam sides and the best width for beam bottoms can be easily taken from the plans by one familiar with form work.

Stock for beam cleats and column yokes can be ordered rough, and the quantity can be closely estimated from the assembly plan. Rough plank and timbers for staging and runways should also be included in the order.

By getting a schedule of the form lumber in this way as soon as possible after the contract is secured there is usually time for a thorough canvass for prices and delivery. At the same time the contractor knows that the quantity called for on the lumber schedule takes care of, and is suitable for, the needs of the job. In this way the very lowest price is secured on the majority of the stock needed for the building.

---

*Paper, substantially in full, presented before convention of American Concrete Institute, Chicago, Feb. 14-17, 1916.

From the assembly of the columns and walls a schedule of the number and lengths of rods and fittings needed for tying the forms together can be made and the order placed early. It is safer and more economical to use rods threaded at both ends. The thread at one end can be short for a hand nut while the other end can be threaded to give any desired adjustment. A nut and washer can be set by a laborer at the proper point on the long thread so that the carpenters need only use the hand nut on the short thread. If a long thread on each end is desired a nut can be turned up and loosened by a special socket wrench operated similarly to a carpenter's bit stock.

The use of check nuts on a rod to give adjustment in length, depending upon a set screw for its grip, while convenient in some ways, is not economical in the long run. The grip of the check nut is the weak point of the outfit. This makes it impossible to stress the rods to their working strength. If, however, a set screw is overlooked and is not tightened at all a failure is liable to result. The worst that can happen when threaded rods are used is a crushing of the wood under the washer if the bolt is over-stressed. The washers used, of course, should not be the standard cast iron variety, but should be steel plates of sufficient area to develop the strength of the rod when the washer is bearing on wood.

Wooden or Metal Forms?—The possibility of using metal forms must be considered when planning the form work for any concrete structure. Where it is possible to use the same units many times without remodeling, or by making adjustments easily provided for in the metal forms, the latter are usually an economy; on sewers, pipe lines, subways, straight wall work, etc., they can usually be used to advantage. In building work the use of metal forms, except for round column and column heads in flat slab construction, is of doubtful economy.

It is usually impossible to get enough uses out of the metal forms on one building to make the first cost even or at least compare favorably with wood. Then again the building must be designed for the standard form units or there is the expense of buying special units which are of no use after the building is done.

The company with which the writer is connected has recently used one well-known make of sheet metal forms on the exterior walls of a group of five buildings having a total of 267,000 sq. ft. of contact surface. These wall surfaces were at first thought ideally adapted to metal forms, but when the elevations were laid out and the task of fitting standard units to them began many obstacles were encountered on account of irregularities. Many special panels had to be purchased and a great deal of wood used for the fitting. By this office study many problems were encountered and solutions found long in advance of erection, thus saving time and expense on the job.

On this job the forms were used an average of 13½ times, at a labor cost of 9.23 ct. per square foot for making, erecting and stripping. The total cost, including material and plant, was 12.93 ct. per square foot. These figures include office expense of the job and were made by an organization enthusiastic over the use of steel forms, and they are as good as may be expected on general work.

One bad feature found with the particular form we used was the cost of purchasing extra wedges and keys. Of a total cost of 2.7 ct. for material, 0.5 ct. was for extra keys. These were loose parts easily lost. There are makes of steel forms which do not have this disadvantage and for this reason might reduce the cost.

The steel forms on these buildings produced a good exterior, true to line, and required less rubbing down after the forms were stripped than is usually the case with wooden forms.

Sheet metal can be used economically in forming an octagonal head at the top of a square column. When the column sizes do not change in different stories the design is simple. We have, however, used successfully one set of metal heads on square columns ranging from 38 in. in the first story to 20 in. in the top story. The adjustment was made by using a plate on each side of the head in which were punched lines of bolt holes spaced for the reductions. Black sheet metal, No. 22 gage, is usually sufficient for these heads, and it can be easily worked by the sheet metal men.

There are several schemes of patent adjustable metal centering and column yokes on the market which have merit for particular cases and should be investigated when considering form material. Material of this kind, which can be rented, is more attractive to the contractor, who dislikes to fill up his plant yard with equipment not always usable and to pay freight charges when lumber can be picked up locally, quickly, and cheaply.

Corrugated sheet metal for slab forms can be used economically on some buildings, especially those of the flat slab type. The corrugated ceiling, however, is objectionable to some owners. When a large number of inserts need to be placed the use of metal sheets is of doubtful economy, because it is more difficult to attach the inserts to the metal forms.

The sheets are laid over the wooden joists, lapping the metal at the ends and sides. These sheets can be reused many times and re-corrugated on the job. When unfit for forms the sheets can still be used for concrete chutes and as siding for temporary buildings on the job.

Shop Work.

Saw Mill and Yard.—The saw mill should be located after a study of the job site in a position where there is plenty of space for piling the stock and finished panels. The saw mill shed and equipment should be standard so that it can be erected and put in operation as soon as possible in order to reduce hand sawing to the minimum. A saw mill at its best is dangerous. For this reason every precaution should be taken to protect the workmen by efficient saw, machine, and belt guards. The mill should be near the building so as to reduce the cost of moving panels. This moving cost is an important item in obtaining low erection costs and will amount to a considerable item when the mill is poorly located, either from lack of planning or from lack of space for the plant around the building.

The mill yard should be so arranged that the stock will go in one direction from the lumber piles to the saws to the making-up benches and to the finished panel piles, which should be nearest the building.

The lumber when received is checked as to quality and quantity. The stock is then sorted and piled according to size and length, each pile having its size plainly marked.

It is then an easy matter for the mill man to make a lumber ledger of all the stock in his yard. Thus at all times it is possible to know the stock available, for as the lumber is used deductions can be made and the running total kept up to date.

Shop Procedure.—The mill man divides the panel details into boards to make the required width of the panel. The number of boards of each kind needed to make the number of panels wanted are ordered moved to the saw to be cut to proper length and thence to the make-up bench, where cleats of the proper size and length are already waiting, having been previously ordered through the mill. Another order to the bench carpenters, which is clipped to a blue-print sketch of the panel, enables them to cleat together the boards into the finished panel. The panel is then taken away by a laborer, stenciled with its location mark, oiled and piled until ready for use in the building.

All this is done by orders written on standard order forms of three kinds, one for moving the stock, another for sawing, and the last for making up. Duplicates of the orders are placed on the mill man's progress board so that he knows at all times how the work is progressing, for when an order is completed and returned to him its duplicate is taken down. Each kind of order is of different color so as to be easily identified.

There are several points in connection with making up panels which may be considered here.

As much assembling as possible should be done at the bench. Rangers for wall beams can be attached and ledgers to support joists can be nailed to the interior beam side cleats at the proper depth. When inserts need to be placed in the sides of beams the holes for the bolts which hold them can be located on the details and the holes bored at the mill. The groove strip for steel sash and also the corner fillet can be put on the column sides and beam bottoms. Bevel key strips for walls should also be nailed lightly to the panels when necessary.

Heavy cleats for big wall columns should be cut and bored, but not attached to the panels. The panel can be cleated with 1¼-in. boards, and is thus made much lighter and easier to handle in erecting. Cleanouts at the bottom, on two opposite sides of all columns, should be made at the mill. Reduction strips should be nailed at the edge of all panels which reduce in size when re-used.

All small pieces liable to get lost or used for other purposes can be dipped in red paint so that their small size will be respected by the carpenters when looking for loose boards.

Much waste in making up ⅞-in. panels can be prevented if the floor is laid out to make the majority of the panels a whole number of boards wide. Roofers come 5⅜ to 5½-in. wide, and it is an easy matter to plan the panels to come, say, seven or eight boards wide, which means no waste in ripping one board to make the width. The lengths should be planned as near stock lengths as possible. Panels made of spliced boards are expensive to make and are easily broken.

New or Used Material?—It is not economical in labor to make up panels from lumber which has already been in contact with concrete several times. On a large building recently erected by us the average cost of making all panels from new stock was $1.10 per square. On another building of exactly the same type the average cost of making all panels was $1.43 per square. On the latter building old lumber from the first building was re-used in making a large part of the panels. These prices include oiling, lumping, saw filing, carpentry, sawing, and job mill overhead.

If, however, panels are in good condition, they can be cleaned and repaired at a considerable saving, both in labor and material. As an example, 13,562 sq. ft. of ⅞-in. floor panels were cleaned, repaired, cut to a new length, oiled, and piled; 6,560 sq. ft. of 1¼-in. column sides were cleaned, repaired, oiled, and piled; 1,250 sq. ft. of column heads were cleaned, repaired, oiled, and piled; at a total cost of $99.25, or a unit labor cost of $0.00466. The estimated labor cost of making the above forms from new stock, using unit costs obtained on the same work, was $178.20, or a saving of over 40 per cent in labor, besides a big saving in material.

Old 1¼-in. panels can be knocked to pieces and the boards cleaned and piled for about $3 per M ft. B.M. Large quantities of typical forms can be made from these boards at a slight increase in labor cost over using new stock. The lumber saving is considerable. The quantity made must be large to allow a thorough routing of the old stock through the mill.

Cleat Spacing.—The cleat spacing for the various kinds of panels should be kept uniform so that the strips on the benches, for spacing the cleats, will not need to be moved for every set of panels.

For beam sides 2x3-in. cleats, flat, can be used on panels up to 30 in. deep; 2x4-in. flat, up to 42 in.; and 3x4-in., on edge, above 42 in. deep. Nails should be specified as follows:

No.	Size.	Width of board, in.
3	10 d	6¾ and 7¾
2	10 d	2¾ to 5¾
1	10 d	Less than 2¾
	12 d	In 3x4 cleats
	8 d	coated and clinch ends in ⅞ boards

Wire nails should be used for form work because of ease in driving and drawing. The holding power is also sufficient. Double-headed nails should be used in securing all boards which have to be loosened before stripping.

Field Work.

All work on the forms after the finished panels are piled at the mill will be called field work to distinguish it from the work in making up the forms, which has been called shop work. Under this head will come everything connected with using the panels on the building. An important feature of this work is a planning department, whose business it is to plan the work in advance so that at all times the several gangs will have definite tasks to do and be supplied with sufficient material with which to do the work.

Planning of Field Work.—An editorial in "The Contractor" of May 15, 1915, says in this connection: "This planning consists of many things. First, it demands complete plans and drawings for the work in hand. Plans can not be made for building a structure unless the details of design have been prepared, and from these the kinds and quantities of work are known." In the writer's own work complete plans are rarely available when work begins, and usually only very preliminary drawings have been prepared. Nevertheless, the work should be planned, using experience on past work and available information on the job at hand as basis to work upon.

The moving boss has an important position in this field work. He is responsible for getting the proper panels to their correct location in the building and for having all other stock called for on the assembly plan on the job ahead of the erection carpenters. When the forms are stripped he must move the panels, which are to be re-made before their next use, to the re-making benches, and thence to their next location. It is expensive to have high-priced carpenters waiting for stock or using stuff not suited for the job they have to do.

The erection of the centering and the assembling of the panels, after the latter have been moved to their proper location in the building, are done by carpenters. It is economical to employ good carpenters and to keep them employed constantly. A gang of men that understands form work on concrete buildings, the methods used, and the grade of work desired, is a valuable asset for any firm specializing in reinforced concrete work.

A competent foreman should be in charge of all carpenter labor. He should be consulted by the planning department so that "team work" will prevail.

Quality in concrete building work is usually more desirable than low costs. Good lines and surfaces will be remembered after the cost is forgotten. These results can be obtained only by careful supervision of the erection of forms.

Stripping of Forms.—When forms are to be re-used, as is usually the case, stripping should be done as carefully as possible. An intelligent foreman in charge of a stripping gang is a good investment. Any man can wreck forms cheaply, but a man who can strip the forms and leave them in good condition for re-use is in the end the cheapest stripper. He saves the time of the high-priced carpenters in re-making and fitting broken panels.

The question of when to strip is one for the building designer to decide, and his instructions should be carefully followed. It is cheap insurance to make enough forms so that no chances need be taken of weakening the structure by stripping while the concrete is still green.

The panels which need to be altered before re-use should be re-made from the blue-prints showing the necessary changes. A bench for this purpose can be set up in the story where the forms are stripped. It is sometimes advisable in a high building to set up power saws in one of the upper stories for cutting off panels and getting out stock for re-making and repairing.

A large gang of carpenters working overtime is sometimes necessary in order to deliver a building on time. This is expensive, however. The workmen cannot give back in efficient labor the value of their high wages. Ten hours is about all the average man can work without falling off greatly in efficiency. Night work on forms should be avoided if possible.

When speed is not the essence of the contract there is time to plan the erection work more carefully. Smaller gangs can be used and their tasks and the material for them routed by slips similar to those used in making up panels.

An important item in the field work is the erection of economical safe stages. The stages should be carefully designed as to the worst possible load to come upon them, and the design should be strictly followed in the field. A man thoroughly familiar with lumber should be made inspector as to the quality of the stock used for stages. A good stage makes the workmen more efficient and is a good insurance investment.

General Notes on Form Work.

The keynotes to economy in a concrete building are regularity and simplicity. These two points, if borne in mind by the designer, make cheap forms. The latter should have the idea of forms as firmly in his mind as he does his bending moment formula if he is to turn out a good reinforced concrete design. Concrete used with brick curtain walls can be worked into very pleasing exteriors without the need of elaborate details requiring expensive forms.

Projecting belt course break up the continuity of the exterior column forms and should be avoided except on very high buildings. A heavy overhanging cornice, consoles, and brackets needed at the top of a tall building can be more cheaply made of sheet metal and attached to a plain concrete cornice beam by means of steel brackets. The effect is just as pleasing as if expensive forms are made and the concrete members cast.

The number of different sizes of beams, columns, and thicknesses of slab should be kept a minimum. This means fewer different kinds of units. The panels can be made and handled more cheaply, to say nothing of the time saved in designing. The biggest item of expense, however, is that of re-making beams and column forms and patching floor forms when changes occur in the size of the members on different floors. It may be nice to know, for instance, that an 18x18-in. column is sufficient to carry the load, but it is better to know that a 20x20-in. column, as used below, is the size to use ordinarily. This saves re-making the column sides and patching the beam and slab forms. In most cases concrete is cheaper than altering forms.

Stock sizes of lumber should be kept in mind when dimensioning the concrete members. For example, projections should be made 1¼ in. and 1¾ in. instead of 1 in. and 2 in., since dressed stock comes nearer the former sizes. Beams can be made 11¾ in. wide instead of 12 in. Thus one 12-in. plank can be used without needing a ¼-in. strip tacked to the edge. Points such as these, thought out in the designing room, mean a cheaper building.

It is economical on jobs where speed is not required to place concrete with light equipment and slowly. Lighter forms can then be used because the live load is greatly reduced when tracks and big cars do not need to be supported by the forms.

Conclusion.

Much has been written, many experiments made, and standards adopted in relation to concrete and reinforced concrete design. It is the writer's opinion that more accidents can be prevented and money saved by contractors and for owners by showing the same interest in the study of form work. The greatest proportion of the small number of failures of concrete structures is due either to faulty form design or because the forms were stripped too early.

Recently we have had reported in the engineering periodicals the failure of a concrete slab, resulting in the death of two workmen. According to an expert's report "the form supports were faulty." Forty-five square feet of floor were supported on each post, made up of one long 2x4-in., to which were spiked short pieces of 2x4-in. to make up a 4x4-in. post. These posts had little bracing. Two floors of green concrete were supported on such posts. Is there any wonder that failure resulted?

As has already been stated the unit cost of making a thorough study of forms for a job is difficult to determine, but it is small compared to the time saved in the field by using the more efficient methods. In spite of the fact that carpenter's wages have steadily increased, while the quality of labor has decreased, and a poorer grade of lumber costs more than a few years ago, unit costs on form work are much lower than when the job was left to itself. The overhead cost for this office work is a very small part of the total unit cost of the form work.

It is safe to say that by using methods such as have been described a larger saving is possible than by doing the work by ordinary method. If this paper helps to create further study and discussion upon the subject of concrete form work, it will, I believe, have justified its existence.

SOME CONSTRUCTION COSTS OF NEW YORK STATE ROADS.*

By H. E. Breed, Deputy New York Highway Commissioner.

Up to Jan. 1, 1916, New York state has completed 238 miles of brick pavements. The average cost for brick pavement on 5-in. concrete foundation is, per mile of 16-26-ft. highway, $25,750. The average cost per square yard of pavement only is $2.015. These figures were obtained from an average of 23 highways.

In order to get a comprehensive cost of other types in New York state I will give figures on waterbound macadam, bituminous macadam and cement concrete:

Waterbound macadam:	
Cost per mile of 16-26-ft. highway	$10,250.00
Cost per square yard of pavement only	0.648

The cost per square yard was obtained from 434 values, and the cost per mile from 419 values.

Bituminous Macadam:	
Cost per mile of 16-26-ft. highway	$12,970.00
Cost per square yard of pavement only	0.871

Both of these items were obtained from the average of 134 highways.

Cement Concrete, 6-in. Thick:	
Cost per mile of 16-26-ft. highway	$15,320.00
Cost per square yard of pavement only	1.121

Both of these items were obtained from an average of 20 highways.

It will be noted that the difference between the pavement cost and the total cost of the highway lies, in all cases except brick, between $4,000 and 5,000. The reason why the cost of items other than pavement is apparently high on brick roads is that the cost of edging has been excluded from the pavement cost, and included in the total cost.

It may be interesting to note that up to Jan. 1, 1915, there have been built in the state of New York 5,167.19 miles of all kinds of highways; during 1915 this department built 1,083.35 miles, making a total of 6,250.54 miles of road. At the present time (January, 1916) there are 783.05 miles under contract which are not completed.

HINTS ON THE CONSTRUCTION OF VITRIFIED CLAY SEGMENT BLOCK SEWERS.†

By J. M. Egan, Jr., Civil Engineer, Aurora, Ill.

At the present time, there are on the market two vitrified sewer blocks of different design, one being a single-ring block and the other a two-ring block. The single block has a ship-lap joint on the ends and a tongue and groove joint on the sides, while in the double block, the laps and joints are made in the construction of the sewer and the blocks are placed one on top of the other as in a two-ring brick sewer. The blocks are hollow longitudinally with web braces. They are made for sewers varying in size from 30 to 108 in. in diameter, and according to size, weigh from 40 up to 120 lb., are 18 and 24 in. long, are from 9 to 15 in. wide, and are from 5 to 10 in. thick. Short lengths are also made for convenience in construction and for use on sharp curves. Special blocks are also made for connections and junctions and consequently this type of sewer is as flexible as any pipe, brick, or concrete sewer. The blocks are also made for use in egg-shaped sewers, in which case, an extra heavy base block is furnished.

---

*Extract from a paper read at the Pittsburgh meeting of the American Road Builders' Association.

†From paper before annual meeting of Illinois Society of Engineers and Surveyors.

In constructing the sewer with the blocks, the method of excavating the trench does not vary from methods used in constructing sewers of other types. If the soil excavated is stiff enough to permit, the bottom of the trench should be shaped to conform to the outside of the sewer, thus forming a good foundation and eliminating excessive tamping. A template may be used to procure this shape as well as a means of guidance for laying the blocks. The first block is laid in the center of the trench to line and grade and the blocks comprising the invert are laid to it. As the blocks of the invert are laid up, care in back-filling behind the blocks must be practised. The joints, both end and side, must be mortared about ¼ in. thick, and the blocks must be laid broken or staggered. The joints of the invert may be pointed up as they are laid. Careful tamping on each side of the spring line behind the blocks will give much added strength to the sewer and this tamping should continue to the second course above the spring line. Wooden forms are used for the arch and are usually placed a little bit higher than the required diameter in order to allow a little wider space for the key block. The blocks are then laid up on either side of the form, the key block finally inserted, the form immediately removed, and the arch will then settle into place and form the correct diameter. Backfilling can then be started at once. In laying these blocks, experienced brick layers are not needed, as the ordinary pipe layer can soon pick up the art of laying the blocks. If wet and quick sandy conditions prevail in the trench and sheeting is necessary, it must be driven low and cut off and left in the trench below the spring line. In cases where steel sheeting would be used, very careful backfilling must be resorted to and as the sheeting is slowly pulled, water flushing must be carried on as it is very necessary that a good bearing be given the invert. In cases where the soil conditions in the trench bottom are very bad, planks may be laid under the first block or a cradle may be used for holding the first few blocks. However, there are no disadvantages in using the block in bad trench work not encountered in using other materials and it is claimed by some of the engineers that have used them in bad trench conditions, that they are to be preferred to any other type of material.

The cost of laying the blocks, of course, varies with the efficiency of the contractor and his organization, and with the varying labor conditions. It should not exceed 1 ct. per inch in diameter of the sewer per lineal foot; this to include labor of laying, cost of mortar, and backfilling up to the spring line. The cost of the block is moderate and has the advantage over the large sewer pipe in that it takes a smaller freight rate, the breakage in transit is exceedingly small, and the cost of handling from cars to trench and in the trench is low as it is easily a one-man job. The cost of the block sewer complete is undoubtedly lower than the cost of either the brick or reinforced concrete sewer, and on account of its lower coefficient of friction, smaller sewers may be used with as good results as larger sizes of the other two materials with a consequent lowering of cost. There is only 7 per cent of surface exposed to the jointing material in the block sewer as against 28 per cent in the brick sewer, and the highly glazed impervious block is certainly superior to the ordinary sewer brick. Good speed in construction can be made and it is not necessary to have much trench open ahead of the block laying and, as mentioned before, backfilling can be done as soon as forms are lowered and the work cleaned up generally as it progresses. All of these points tend to lower the cost of this type of sewer with the advantage of giving a more efficient structure.

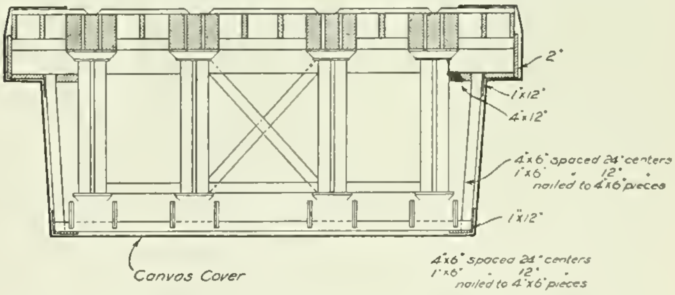
Good connections can be made between segment block sewers of different size as well as between segment block sewers and pipe lines. The segment block sewer can also be adjusted to fit sharp curves with very little loss of efficiency. Special blocks are made for the small connections with the pipe molded to the block and in the large sizes, four or six adjacent blocks are so molded in the manufacture to permit of the entrance of the large pipe and thus saves any cutting or chipping of the block on the construction work. The matter of sub-drainage is eliminated, as the ducts in the hollow block form a sub-drain and the ground water is readily carried off.

These blocks, while being particularly adapted for use in constructing storm and sanitary sewers, are also coming into use as outlet drains for large farm drainage projects instead of small open ditches. They can also be used for service tunnels as well as for highway culverts. Sewers of vitrified clay segment blocks have been constructed during the past few years in many cities in this country and Canada.

Both internal hydrostatic pressure and loading tests have been carried on in connection with this type of sewer and the results of these tests may be obtained from the manufacturers and testing laboratories, it being enough to state here that the strength of the blocks have proven ample and sufficient for the use for which they are made. Examinations of segment block sewers have been made after they have been in use for some time and the reports are that they are in good shape and answering their purpose in every respect. Perhaps one of the most critical tests in actual practice was made at Louisville, Kentucky, where a 72-in. diameter block sewer was examined after it had been in service for two years, being located in a trench 28 ft. deep. The examination showed that the sewer was in perfect condition with absolutely no defects either from abrasion or the weight of the fill above the same.

METHOD AND COST OF MOVING A FERRY TRANSFER BRIDGE.

In constructing the Humboldt Bay jetties in California it was required to move a ferry transfer bridge across the bay. The bridge was of the usual type hinged at the inshore end and supported at the outshore end by gallows frame and counterweights. It weighed 110 tons. For moving the bridge was transformed into a pontoon by building a framework underneath and covering it with paraffined canvass. A section of the transformed structure is illustrated. As a pontoon the structure was unhinged, towed by tugs to its new place and reinstalled, using the same hinge frame and gallows frame. It required 1 hr. 10 min. to transfer the bridge from hinge to hinge. The cost of the transfer as given by G. F. Whittemore, engineer, in "Professional Memoirs" was as follows:



Ferry Transfer Bridge Converted Into a Pontoon for Removal by Towing.

The amount of supplies and labor used in contract is itemized as follows:

Labor	$380.72
Canvas, 48.5′×119′, No. 6 duck	285.00
Lumber	69.54
Supplies	101.67
Insurance	5.75
Boat hire	41.40
Total	$884.08

The amount spent by day labor by the United States on this work, in addition to the contract, is as follows:

Material	$ 000.00
Labor	446.20
Total by day labor	$ 446.20
Total by contract	884.08
Grand total cost	$1,330.28

DESIGN AND COST OF RESERVOIR IMPROVEMENTS AT DULUTH.*

By E. W. Kelly, Engineer, Water and Light Department.

Design and Cost of Woodland Reservoir.—The Woodland reservoir of the Duluth water works was constructed in 1915. It has a capacity of 1,024,000 gal. It supersedes the 80,000-gal. wooden tanks previously in service. A view of the finished structure is shown herewith as Fig. 2.

This reservoir is circular, and is constructed of reinforced concrete throughout. The average internal diameter is 91 ft., and the wall is 21 ft. high from floor to overflow level. The floor slopes downward 1 ft. to the central sump. It has a beam-and-slab roof supported by 16 columns. The roof was added chiefly to retard, by the exclusion of light, the growth of algae which cause disagreeable tastes and odors.

The wall of this structure is 24 in. thick at the bottom and 10 in. thick at the overflow level. A footing 4 ft. wide supports the wall. The floor is 10 in. thick, with ½-in. trowelled mortar facing. Walls and floor are of 1:2:3 concrete; roof and columns are of 1:2:4 concrete. The walls are reinforced with square twisted steel bars as hoops, proportioned for a stress of about 13,000 lb. per square inch, no deduction being made for the stress taken by concrete or for external earth pressure.

The floor is reinforced with ½-in. square twisted bars on 1-ft. centers both ways, with three additional circumferential courses of the same sized bars next the wall. Wall and floor are joined with ¾-in. square bars on 2-ft. centers. The roof slab is 5½ in. thick, reinforced with ⅝-in. square bars on 11-in. centers both ways.

The earth excavated was placed to form an embankment against the wall extending to within about 16 ft. of the top of the coping. In a part of the site, it was necessary to excavate below grade to reach satisfactorily firm foundation. In this portion, Class C concrete was used to bring the foundation to grade.

The entire interior of the wall, and the visible portion of the exterior of wall and coping were painted with neat cement. No other waterproofing was used, and the structure is apparently bottle-tight.

Access to the interior is provided for by two traps in the roof fitted with steel covers. A steel ladder descends from one of these traps to the floor.

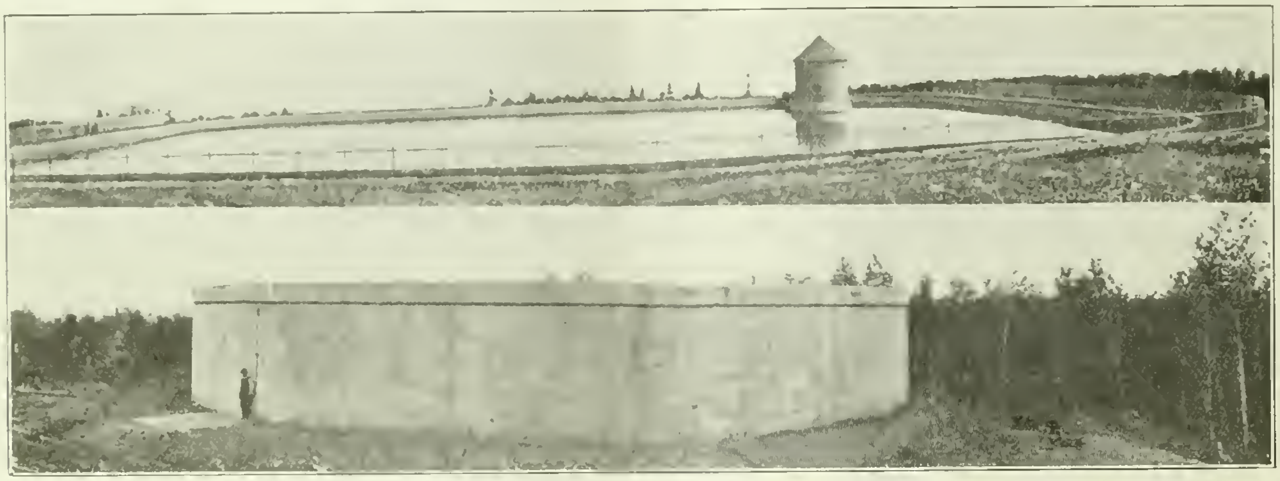
In the 9-ft. square concrete valve chamber are installed the valves and check-valves which are arranged so that water must leave the reservoir on the opposite side to that at which it enters. The cost of this structure complete including connection to the Minneapolis Avenue main was as follows:

	Unit cost.	Total.
1,269.4 cu. yd. earth excavation	$0.50	$ 634.70
158.3 cu. yd. earth excavation in trench	0.70	110.81
0.5 cu. yd. rock excavation	1.50	0.75
103.3 cu. yd. class C concrete	6.00	619.80
98 lin. ft. 12-in. pipe laying	0.47	46.06
189 lin. ft. 10-in. pipe laying	0.40	75.60
10 lin. ft. 8-in. pipe laying	0.30	3.00
48 lin. ft. 6-in. pipe laying	0.23	11.04
Reservoir and valve chamber, complete (Comprising 790 yd. concrete and 60½ tons steel.)		11,750.00
Pipe at $24.45 per ton		323.99
Valves		282.71
4,903 lb. specials	0.033	161.10
Drayage by department		41.08
Electric alarm and conduit		14.66
Inspection of cement and steel		61.61
Miscellaneous labor, material, etc.		48.42
Engineering, inspection, and overhead (3.28 per cent)		480.70
Total cost, including engineering and overhead		$14,666.03

The estimated cost was $15,826.24.

D. H. Clough & Co., the contractors for this structure, carried the work through in an eminently creditable and satisfactory manner.

Steel Fence at Reservoir "A."—A steel fence was erected around Reservoir "A" to exclude animals and loiterers. This fence is 7 ft. in height, and consists of 1¼-in. x 3/16-in. angle pickets 6 ft. 9 in. long, with top end sheared to a point, on 7-in. centers, set in two 2x2-in. channel rails. Posts are 3-in. I-beams set about 10 ft. apart in concrete piers. The fence is set 1 ft. outside the stone gutter of the driveway around the reservoir, following the circular curves at the corners. A view of the fence is shown in Fig. 1.



VIEWS OF TWO WATER WORKS RESERVOIRS AT DULUTH.
Fig. 1—View of Reservoir "A" Around Which a Steel Fence was Erected in 1915. Fig. 2—View of Woodland Reservoir, Erected in 1915.

Steel work was manufactured by the Anchor Post Iron Works. Erection was done by this Department. Detailed cost of this fence was as follows:

Steel, posts and gates (about 23¼ tons)	$1,615.00
Sand, gravel and cement	74.75
Hauling steel, sand, gravel, cement and spoil	144.77
Labor and superintendence	330.28
Engineering	35.94
Miscellaneous	7.93
Total cost	$2,238.67

The concrete piers required 35 bbl. cement, 16½ yd. sand, and 30 yd. gravel for their construction.

---

*From 1915 annual report.

CLEAN BRICK ESSENTIAL FOR PERFECT PAVEMENT GROUTING.*

By H. E. Breed, Deputy New York Commissioner of Highways.

Another point to which it has been necessary to give very careful attention is the washing of brick. Many times brick are stored in piles along the road so long in advance of the construction work that they are so spattered with mud from passing traffic and so covered with dust that it is doubtful whether the grout will properly adhere to them. In all cases of this kind I strongly urge that the brick be thoroughly washed, so that the grout will have an opportunity to perform its full function in cementing them together. It is well known that if the grout does not perform this function the individual bricks become loose and the sand cushion shifts on the absorption of moisture, so that in a short space of time it is badly in need of repairs. A large percentage of the bad results which we discover in our maintenance work is due to the fact that the grouting did not perform its full function and cement the brick firmly together.

---

*Extract from a paper read at the Pittsburgh meeting of the American Road Builders' Association.

PRACTICAL NOTES ON THE DESIGN AND CONSTRUCTION OF OPEN DRAINAGE DITCHES.*

By A. L. Goldenstar, Civil Engineer, Mankato, Minn.

. Since engineers have been able to base their estimates on open work on dredge prices it seems to be common for many of them to specify a ditch section that is particularly suited to dredge work. It usually has been a section with rather wide bottom and steep side slopes. Side slopes of ½ to 1 have been very common and some have been even steeper. The arguments in favor of such a section have been that the sides were expected to cave down and the ditch would finally assume a section of its own that would stand, and second, that there would be little trouble in getting a contractor to dig the required section, because it is the easiest and most natural one to cut with a dipper dredge. But instead of the channel becoming an ideal one the sides are always rough and ragged, never cease caving in and the ditch fills up above grade clogging up the tile outlets that may be in it. The argument that nature will form the proper form of channel seldom holds good.

In my observation I have seen no instances where a permanent side slope of less than 1 to 1 has ever been successfully maintained. For the ordinary soils of northern Iowa and southern Minnesota, I think that 1 to 1 should be the minimum slope and 1½ to 1 is often better. For loose, sandy soils even flatter slopes than these should be used. In order to avoid excessive top widths with these flatter slopes the bottom may be kept comparatively narrow. This will aid in making the ditch self cleaning. In standard railroad and highway construction the slopes for excavation in cuts are never less than 1 to 1 and 1½ to 1 is now commonly specified. The slopes of railroad and highway cuts are exposed to even less erosive forces than the sides of open ditches.

But the proper construction of an open drainage ditch does not begin and end in specifying the right cross section. Means must be taken to create absolutely the form that is desired. In this connection I would like to bring out a few points of success and failure of our common methods of open ditch construction. Where teams and scrapers can be used it is comparatively easy to secure smooth sides and bottoms without much hand labor. But teams and scrapers can be used in very few places so we must reckon with the dipper dredge or the dragline machine. Dipper dredges cannot cut a smooth enough or true enough side slope or bottom without the help of hand labor. Then also these machines are usually started at the upper end of a ditch and proceed down stream. I think there are only two arguments in favor of this method of procedure. The first is that it insures a good supply of water that will lubricate the dipper and make dumping easy, and the other is that it provides the necessary amount of water to float a floating type of machine. From all other points of view this method is detrimental to the job. The machine is always digging under water so that the operator can never see what kind of slope he is digging. When the dipper full of material is raised up through the water all the loose particles will wash off to remain suspended in the agitated water until the machine has moved on. Then this matter settles to the bottom in the form of silt. I have seen from 2 to 4 ft. of this silt in a semi-liquid condition behind a dredge. It is usually assumed that this will all wash out with first flood but it never does. Keeping the ditch full of water makes trimming of the sides by hand or any other means impossible. The wet plastic material dropped on the spoil banks settles so firm and tough as to make subsequent spreading very difficult.

The dragline machine seems to be coming into more general use now for wide open channels. Greater care can be taken with this type of machine in cutting the true cross section channel. The sides can be left smoother since a wide flat bucket is used. Also the spoil can be dumped over a wider area which reduces the amount of spreading.

Other types of excavator are being used but only in a few cases. The so-called "template" excavators are made but experience with them is very limited in this territory. They still seem best adapted to dry land work.

In the light of the experience we have had with the various dredging machines I think we can say that there is room for much improvement. I think that the dredging machine is still to be invented that will by its own work, without assistance, make a first-class open drainage ditch. The kind of ditch I have in mind is the common sized channel with from 4 to 16-ft. bottom. For the larger channels the present machines may suffice but for the smaller ones they are not satisfactory.

The first logical step to be taken in handling this problem is to specify exactly the section that is desired and then insist that it be built that way. This will foster the designing of machinery that will build this section. Whether the dipper dredge and dragline machine can be improved to do this or whether some sort of a template excavator must be invented that will move cheaply all kinds of earth remains to be seen. At any rate a change must be made or we will continue making open ditches that are a continual expense to maintain and never permanent. Instead of designing ditches that the present machinery can build we should try to develop machinery that can build the ditch that will stand.

In this paper I have not discussed the open ditch from the standpoint of capacity. To determine the proper size of waterway to drain a certain number of acres is a problem in itself. What I am contending for is an open drainage ditch that will withstand to best advantage the destructive forces that will come upon it, and the machinery that will construct this kind of ditch. Until somebody invents something in the form of large pipe or concrete lining to take the place of the open ditch we will still have open drainage ditches to construct and maintain.

THE CONCRETE BRIDGES AND VIADUCTS OF CINCINNATI, OHIO.*

By Frank L. Raschig, Principal Assistant Engineer.

Previous to 1910 there was only one reinforced concrete bridge in Cincinnati, Ohio; since 1910 the city has expended about $2,000,000 for concrete bridges and viaducts, of which $1,300,000 were spent on construction and $700,000 for property. Two viaducts have been finished, 2 are now under construction, 15 bridges and viaducts of lesser importance have been built, and about 30 small bridges have been constructed to replace wooden structures. It is the settled policy of the Engineering Department of Cincinnati that none except concrete bridges and viaducts are to be built in the future unless absolutely necessary. The following data refer to concrete bridges, built or under construction in Cincinnati:

Gilbert Avenue Viaduct.—This viaduct, a portion of which is shown in Fig. 1, lies in the heart of the city and was built as an extension of Gilbert Ave., a wide thoroughfare leading to Walnut Hills, a suburb of about 50,000 inhabitants. The structure is a strictly viaduct type consisting of short spans of column, girder, and beam construction. This type was adopted in preference to one consisting of long spans for two principal reasons. It was thought that in the locality where the viaduct is built that arches would not show to advantage, as they would lie close to the ground and, being surrounded by buildings, the whole structure would not be seen at one time. A long span was necessary only at one location, Eggleston Ave. A second reason for choosing this type was low cost, as was demonstrated by the bids received. There was a great saving in foundation work, as the weight of the present structure is only about one-half that of arch construction. The foundation required piling.

The viaduct proper is 1,036 ft. long and consists in general of 30-ft. spans of reinforced concrete; over Eggleston Ave. there is a 100-ft. steel girder span en-

---

*Extract from paper read at the meeting of the Iowa State Drainage Association.

*Extracts from paper before convention of American Concrete Institute, Chicago, Feb. 14-17, 1916.

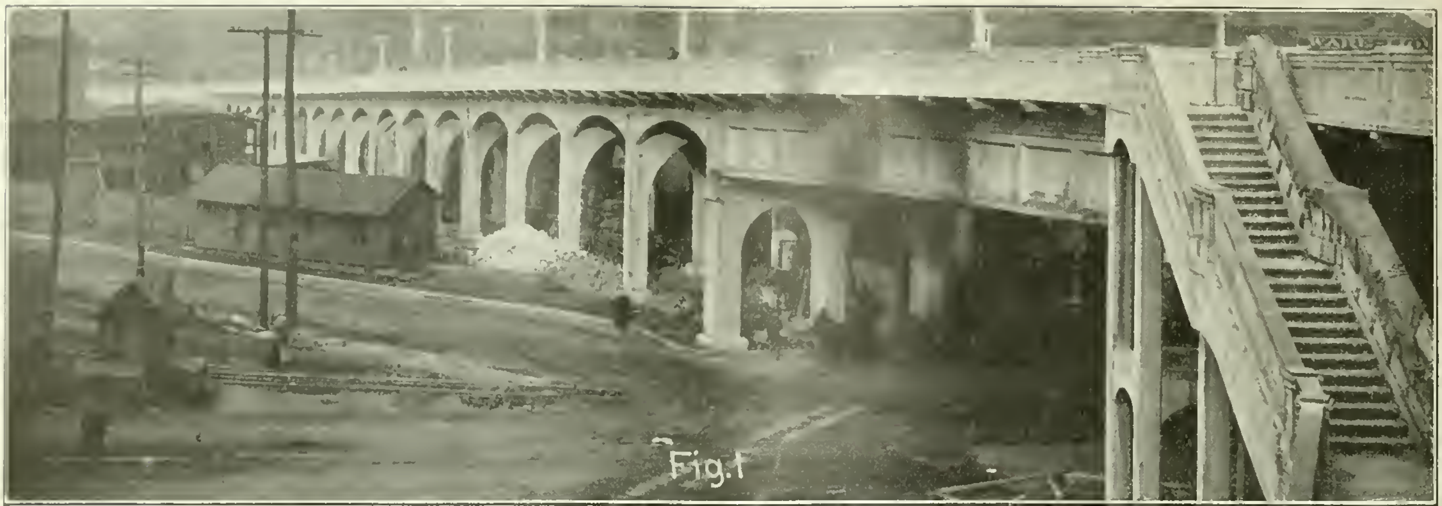


Fig.1

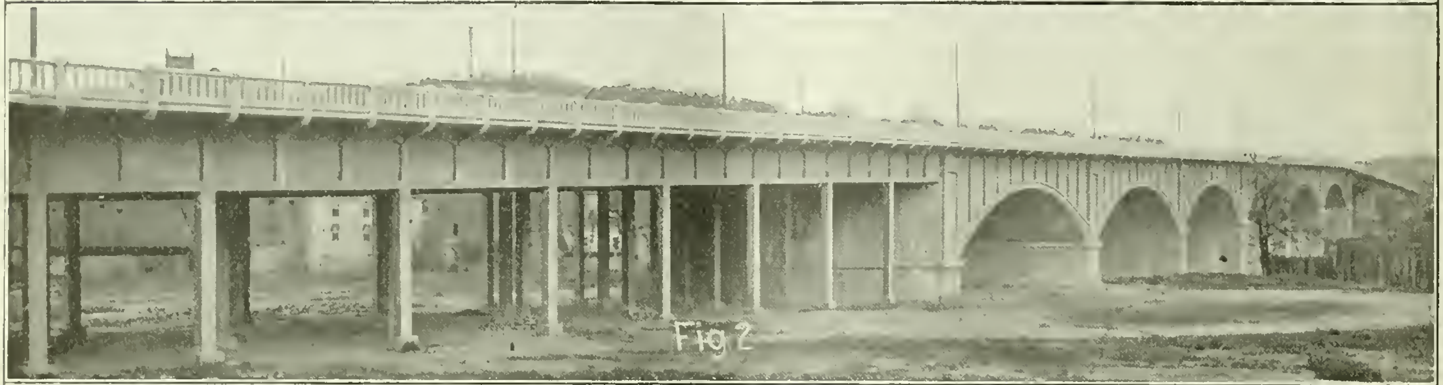


Fig.2

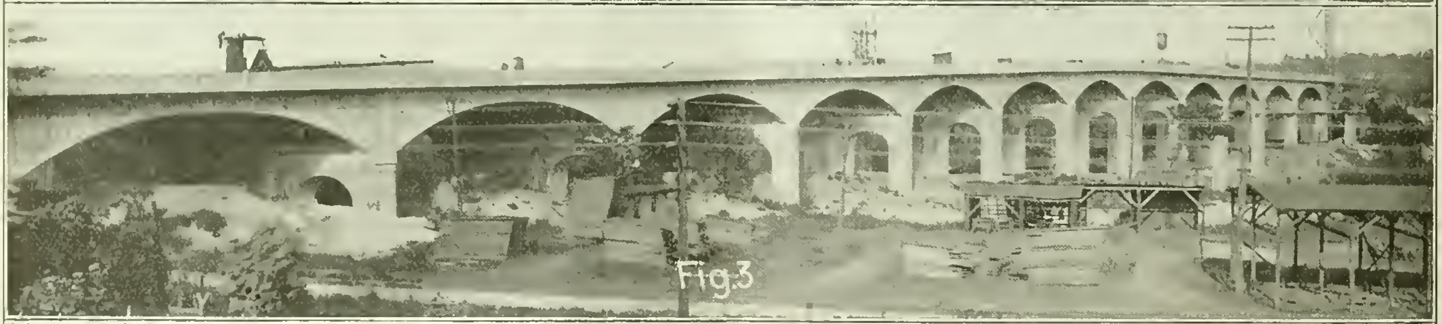


Fig.3

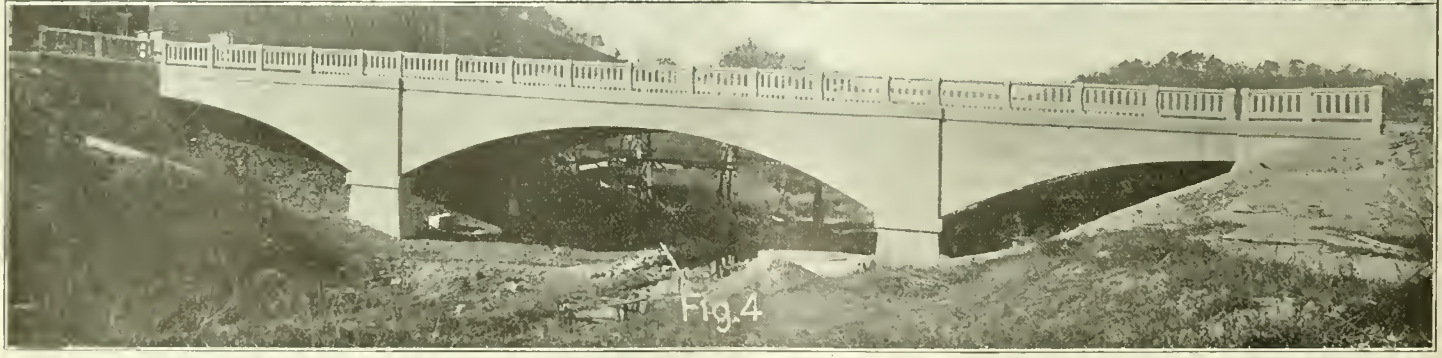


Fig.4

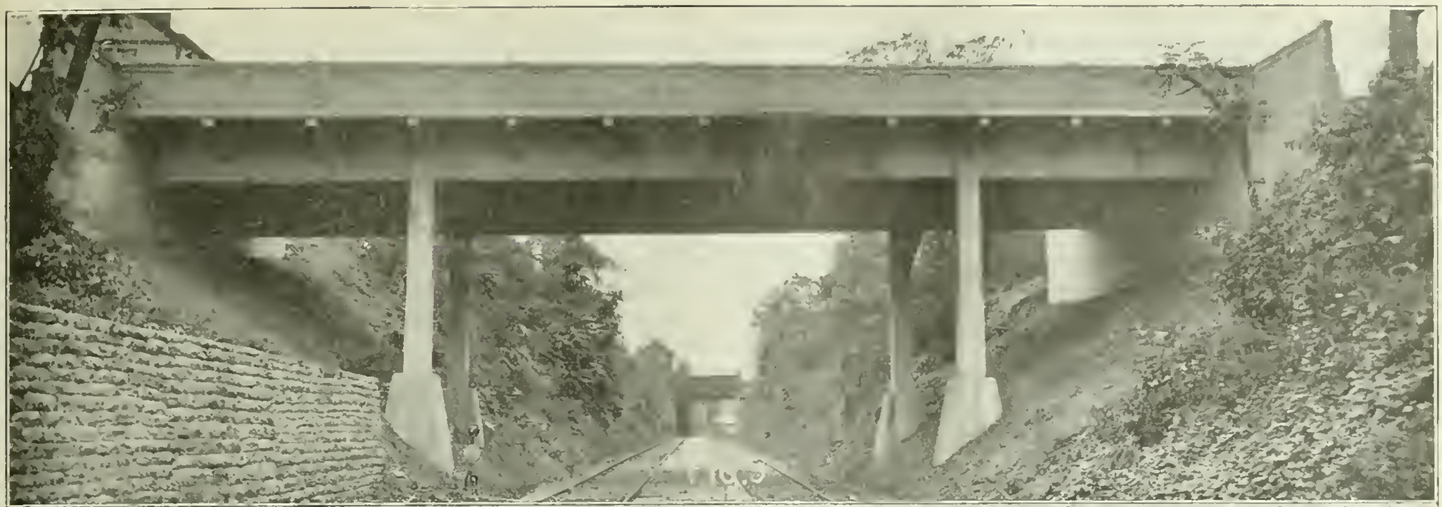
VIEWS OF SOME REINFORCED CONCRETE BRIDGES AND VIADUCTS BUILT IN CINCINNATI, OHIO.
Fig. 1—Portion of Gilbert Ave. Viaduct Adjoining Eggleston Ave. Fig. 2—West Elevation of Ludlow Ave. Viaduct. Fig. 3—Partial View of Hopple St. Viaduct; Spans Are Balanced Cantilevers. Fig. 4—Runnymede Ave. Bridge; Cantilever Construction.

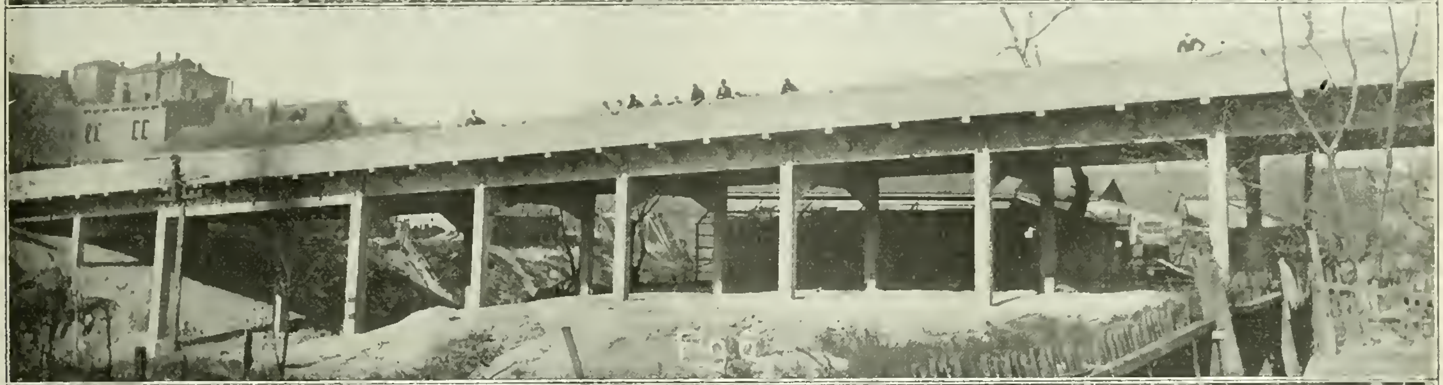
cased in concrete. The viaduct is 80 ft. wide overall, with a 58-ft. roadway and two 11-ft. sidewalks. The maximum grade is 3 per cent, the roadway being paved with wood blocks. Double tracks for street cars are provided. The 30-ft. spans are of beam and girder construction and are supported by rows of four columns. The concrete proportions are 1 part cement, 2 parts sand, and 4 parts crushed gravel 1 in. and under. The viaduct is founded on Simplex concrete piles. The total cost of the viaduct, including the paving of intersecting streets at each end, was $270,000, or $240,000 (about $2.40 per square foot) for the viaduct proper.

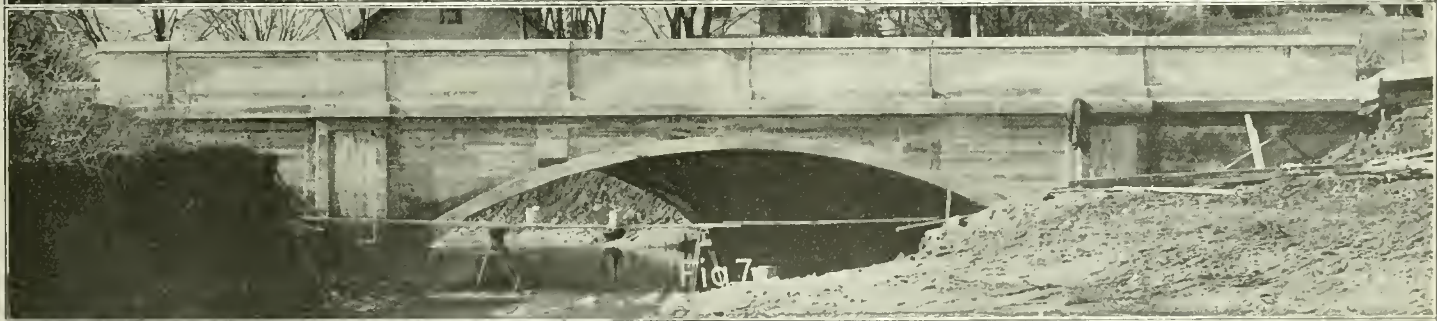
Ludlow Avenue Viaduct.—This viaduct was built to eliminate a dangerous grade crossing. A new route was selected for the street to provide a more direct route than that of the old one; this eliminated all curvature. Figure 2 shows a portion of this viaduct.

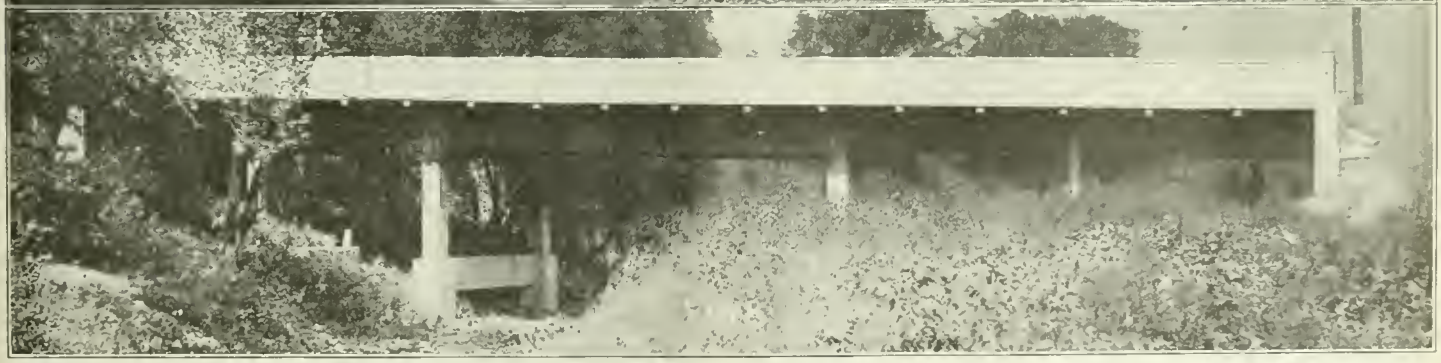
The viaduct proper is about 1,336 ft. long and 60 ft. wide, with a 40-ft. roadway and two 10-ft. sidewalks. There is a 110-ft. girder span encased in concrete over the railroad tracks; at the middle of the span over Mill Creek there are six solid-barrel arches of 85-ft. clear span, on a skew; at each end the construction consists of cross girders carried on rows of reinforced concrete columns spaced about 24 ft. apart, these girders supporting longitudinal beams which carry a reinforced concrete deck. The roadway has a maximum grade of about 5 per cent and is paved with brick. The viaduct is founded on Raymond concrete piles.

The general architectural treatment of the viaduct was difficult, both on account of the heavy grades on the structure and the combination of arch and beam-and-girder spans. The appearance of uniformity was obtained by using the same spandrel detail for the fascia









SINCE 1910; THESE INCLUDE ARCH SPANS, CANTILEVER SPANS AND BEAM-AND-GIRDER SPANS.
Fig. 5—Whittier St. Bridge Over C., L. & N. R. R. Fig. 6—Burbank St. Bridge Over C., L. & N. R. R. Fig. 7—Arch Span Over Duck Creek on Plainfield Pike. Fig. 8—Powers St. Bridge Over West Fork Creek.

beams of the approach spans as is used on the arch spans. The cost of the bridge, including paving and approaches, was $280,000, or about $3.00 per square foot.

Hopple Street Viaduct.—This viaduct is being built to eliminate the grade crossing of Hopple St. and the Baltimore & Ohio Southwestern R. R. It is placed directly over the present street and passes over Spring Grove Ave., the B. & O. S. W. R. R., Mill Creek and the C. H. & D. R. R. The viaduct will be the longest one in Cincinnati, its total length being about 2,100 ft., and the length of the viaduct proper 1,930 ft. The structure is 60 ft. wide, with a 46-ft. roadway and two 7-ft. sidewalks. The entire construction is reinforced concrete. The maximum grade is 2.7 per cent, and the roadway will be paved with wood blocks and will carry two lines of car tracks. A portion of the viaduct is shown in Fig. 3.

The bridge has the appearance of a series of concrete arches, but in reality it is composed of balanced cantilevers. This type of construction was adopted because longer spans could be used than with ordinary girder spans and because it is better suited to a location where arches would be exceedingly costly on account of unsatisfactory foundation conditions. The viaduct consists of 25 skew spans of 70, 75 and 80-ft. lengths, each span comprising two curved cantilever arms supported on reinforced concrete piers. Each cantilever arm consists of four curved ribs, with a joint at the center of each span designed to transmit shear only. The piers, except those carried to solid rock, are founded on Raymond concrete piles. The exterior surfaces of the concrete are to be sand blasted. The bridge will cost about $420,000, or about $3.30 per square foot.

Park Avenue Viaduct.—This viaduct forms the main entrance to Eden Park from the north, crossing a deep valley. It was therefore decided to build, for the main part of the structure, an arch of long span and to make the entire work of an ornamental design.

The viaduct proper is 360 ft. long, the main portion consisting of an arch of 180-ft. span. The arch consists of three ribs and has a rise of 31 ft. The arch ribs support an open spandrel construction which carries a beam and slab floor. The abutments are ribbed and hollow. Leading up to the arch on each side are two 25-ft. beam-and-girder spans supported on rows of three columns. The viaduct is 65 ft. wide, with a 40-ft. roadway and two 12½-ft. sidewalks. The roadway is on a 1 per cent grade and will be paved with wood blocks. The entire outside surface of the structure, except the mouldings, etc., are to be bush-hammered. The viaduct with its approaches, will cost about $135,000, or about $4.00 per square foot for the viaduct proper.

Other Bridges.—In addition to the four structures described there have been completed a number of shorter bridges, some of which will be described briefly.

The Runnymede Ave. bridge (see Fig. 4) over West Fork Creek in Cumminsville is of the cantilever type, no joint, however, being provided in the middle. The center span has a clear length of 65 ft., the total length of the bridge being 140 ft. The construction consists of two longitudinal beams connected by cross beams supporting a concrete roadway 20 ft. wide and two sidewalks each 6 ft. wide. The bridge is on a 5 per cent grade, its total cost being about $19,000.

Another bridge on West Fork Creek is a 50-ft. girder span, 60-ft. wide. The abutments were designed to take the thrust from the earth approach at the top and bottom, struts having been built across the creek to take the trust at the bottom. The bridge therefore is really a large box culvert. The entire structure is founded on Simplex concrete piles, its cost being about $27,000.

Three of the first concrete bridges built in Cincinnati are of the same type—beam and girder bridges supported on columns. These bridges have a total width of 32 ft., the width of roadway being 20 ft. The Whittier Street bridge (see Fig. 5) consists of a 40-ft. central span over two railroad tracks and a 20-ft. span on each side. The cost of this bridge was $6,500.

The Burbank Street bridge (see Fig. 6) is about 300 ft. long, all spans being 24 ft., except the one over the C. L. & N. R. R., which is 40 ft. The spans are supported on reinforced concrete bents. This bridge cost about $14,000.

The Grand Avenue bridge in Price Hill spans a ravine. It is 200 ft. long and consists of five 40-ft. spans of beam-and-slab construction resting on two rows of columns. The bridge is 30 ft. wide, with a 22-ft. roadway and one 6-ft. sidewalk. An elevated concrete sidewalk connects the bridge with the street to the west. The structure cost about $11,000.

Figure 7 is a view of a concrete arch span over Duck Creek on Plainfield Pike, Madisonville.

The Powers Street bridge over West Fork Creek (see Fig. 8) is 130 ft. long and consists of one 40-ft. span and four 20-ft. spans; its cost was about $6,000.

During the past year the city has replaced 30 small wooden bridges with reinforced concrete structures. These bridges are mostly of the beam-and-slab type with iron pipe railings, although several are small arches with concrete railings. The city is planning to replace a certain number of wooden and small steel bridges each year so as finally to have none but concrete bridges.

GRAVEL ROAD CONSTRUCTION IN NEW HAMPSHIRE.*

By Frederick E. Everett, Commissioner, Highway Department, Concord, N. H.

In a good many localities there are deposits of good gravel and where this occurs, it has been comparatively easy to get good results. In numerous other places gravel could not be found or if found it was of an inferior quality lacking in some important feature, perhaps in binding material, perhaps, as is more often the case, in metal. Under the latter conditions we resort to a combination of material to get the desired effect. If the gravel is sandy, with no binding material we alternate the layers of gravel with clay or marl or sometimes mix the two materials thoroughly by harrowing or some such other method. If there is not enough metal we have found that with a stone foundation, material of a very inferior quality can be used for surfacing and with very satisfactory results.

We have in New Hampshire a mixture of clay and sand and gravel called hardpan. This is probably more common than any other native material. This material mixed with sand or sandy gravel or even laid directly on the stone foundation or telford is quite satisfactory under our system of maintenance.

In construction we pay due attention to the essentials, alignment, grading, drainage and foundation. In connection with the alignment it might not be out of place to say just a word as to our methods of survey. Contrary to the general practice adopted by most states, we do not make a plan of the road first and then plot the new road on paper.

The first procedure is to establish the center line of the new road on the ground, correcting the old alignment where possible. With this as a base line we are enabled to stake out the new lay-out also make a survey of the existing conditions. Stakes are set every 50 ft. on an off-set from the center line. When the cross sections are taken an elevation is obtained of the top of these off-set stakes so that when the finished grade is obtained it is easy to determine the cut of fill from the top of these stakes.

If for any reason it is desired to change the alignment after the survey is plotted on the plan the stakes are on the ground and it is an easy matter to figure the off-set either way from them. I believe this method of survey and staking out saves the expense of one engineering operation in the field.

The essentials of drainage and foundation we give particular attention to, for with these gravel or dirt roads it is very necessary that the water be thoroughly taken care of. A great many of our roads have the telford foundation, especially if the gravel is of an inferior quality with a tendency to be heavy or sticky in wet weather.

We have built most of our roads 21 ft. wide from ditch to ditch. In some cases I am inclined to think that this is not wide enough. However, the roads have answered very well for the traffic they are subjected to. Our original specifications called for 15 ft. of metal and with a 3-ft. dirt shoulder. The gravel was laid in three courses of sufficient thickness that the whole compacted mass should be eight inches. Today we believe that we can get better results by subgrading the entire width of 21 ft. in practically a flat section. If, however, the stone foundation is used we crown it slightly. On this section the surfacing material is placed in two courses, using a dumping board or dumping the loads in such a way that all the material will be handled over.

We roll each layer, using in most cases a horse-drawn corrugated roller. Some of the larger towns, however, use a steam roller and some of the smaller ones have no roller and depend on the traffic to do the compacting, keeping it in shape by dragging and raking. Of course we get results quicker where we are able to use a sprinkler and thoroughly wet down the separate layers, but in most cases we have to depend upon nature for the wetting. The finished section has a thickness of metal of about 10 in. in the center and practically nothing on the edges. This gives a crown to the road of about 1 in. to the foot which we believe is necessary for roads of this nature.

We have built in the ten years that the department has been in existence, 1,171 miles of road of which 558 is trunk line, outside of the compact portion of towns having a population of over 2,500. Of this latter amount 422 miles is of gravel construction and represents an expenditure of $1,614,503, or an average per mile of $3,826.

---

*Extract from a paper read at the Pittsburgh convention of the American Road Builders' Association.

Engineering and Contracting

Devoted to the Economics of Civil Engineering Design
and to Methods and Cost of Construction

EDITORS
H. P. Gillette C. S. Hill C. T. Murray S. C. Hadden C. W. Malcolm

Volume XLV. CHICAGO, ILL., MARCH 22, 1916. Number 12.

STANDARD BUILDINGS.

To reduce the cost of buildings, and at the same time decrease the interval between the signing of the contract and the delivery of the finished structure, are the principal objects of a number of firms at present. The present active demand for factory buildings, and the insistence of owners on quick delivery of the finished structures, have acted as a stimulus to such firms, and rapid strides are now being made toward the standardization of certain types of commercial buildings. For some time it has been possible to buy certain small buildings, in units, ready for erection; but some firms are now offering to furnish and erect "standard" factory buildings of large size within, say, 30 to 60 days after the contract is signed, and at an attractive price. The principal development is now being made in the direction of factory buildings, but it is very probable that the movement will gradually extend to other types of commercial buildings as well. The plan of designing, fabricating in units, and holding in stock, a considerable number of large factory buildings before purchasers are found may, at first thought, appear somewhat startling, but present conditions are favorable toward its rapid development.

It can hardly be denied that much can be accomplished toward offsetting increased labor costs by standardizing units and even types of building construction, and, if standardization is not carried beyond reasonable limits, there should be little opposition to it. We have already reached the stage where many units of our commercial buildings have, to a considerable extent, become standardized. Standardization does not necessarily mean a loss in architectural appearance, although it does mean less individuality, and possibly less ornamentation. However, few officials are justified in decreasing dividends to the stockholders of their companies by paying large interest charges on highly ornamental and specially constructed buildings. There is a vast difference between mere ornamentation and true architecture—pleasing lines and correct proportions are entirely possible in standard buildings. Of course we should not care to see —nor are we likely to see—standardization of type carried out in residence construction, nor should we favor standardization of all government or state buildings, but there appears to be a fertile field for standard buildings of the factory type.

WHAT IS WRONG WITH THE AMERICAN WATER WORKS ASSOCIATION?

Our query; what is wrong with the American Water Works Association? presupposes that something is wrong. We think there is something wrong with it but we may be mistaken. We are very sure that the question is in order and is worthy of the thoughtful consideration of its friends. Among the latter the editor considers himself. It may be unnecessary to do so but to forestall any misapprehension as to the intent which prompts this editorial let it be clearly understood that the present discussion is meant to be constructive.

The query with which we have introduced this editorial was suggested by the perusal of a circular letter just received from a prominent officer of the Association—a man who has done a very great deal, in recent years, to get the Association on the right track and headed in the right direction. The letter states that there are 6,000 water works in the villages, towns and cities of the United States, and of this number only 500 are represented by active or corporate members in the Association. These facts should be kept clearly in mind with the fact that the Association has held 35 annual conventions. During these 35 years great effort has been extended to secure new members but today not over eight per cent of the water works men of the country are directly benefited by the Association. Whatever is wrong must be discovered and corrected if the Association is ever to realize its possibilities.

Following the convention at Cincinnati last year several journals published adverse criticisms of the conduct of the convention and of the handling of the Association's business in general. Engineering and Contracting did not join in making those criticisms but they were read with care and in substance were as follows: The membership is more interested in voting on the next place of holding its meeting than in anything else; that too much time is taken up in listening to perfunctory addresses of welcome by the local political and commercial dignitaries; that there is a strong tendency toward the formation of cliques and factions; that the operating men resent the active part assumed in the management of the Association's affairs by the technically trained men; that the prospect of a junket is more alluring to the average member than the opportunity to add to his knowledge of the water works business, etc. The foregoing is not a complete list of the critical comments offered but the others were of like import and nature. One writer raised this query: Can the American Water Works Association Find Itself?

The faults mentioned certainly indicate that something is wrong with the Association. Some will say that many things are wrong; our view is that only one thing is wrong and that all the other apparent faults are merely corollaries of the general proposition: The American Water Works Association Does Not Do Enough for Its Members as Individuals.

Broadly speaking the Association is an engineering society. Its failure is not more conspicuous than that of the average engineering society and springs from the same cause; it doesn't do enough for the individual. Students of engineering society work are very well agreed that the original aims of such organizations are not satisfying now. It is not sufficient to organize, hold conventions, elect officers, read papers and publish proceedings. All those things are necessary but they are not sufficient. The instruction of the individual is not sufficient—something must be done to help him in a more material sense.

Now let us inquire how the American Water Works Association can help its active members in a material sense, and let us take, as an example, a competent superintendent of a municipally owned plant. The greatest aid the association can offer such a man is to help him hold his position against the onslaughts of his political foes. That can be done by giving him some mark of endorsement, some form of certificate of competency from the Association. We believe that plan is workable although it will entail more difficulty, naturally, than the present plan of allowing the individual to shift entirely for himself. If the individual felt the strength of the Association at his back he would be a better official to the everlasting benefit of the community he served. His loyalty to the Association in such event would be great and he would no more think of dropping his membership under such circumstances than he would of lapsing his life insurance policy. Under such a plan of action the non-member would hasten to become a member from selfish, if from no other motives, and would strive to merit the endorsement of the Association.

For 35 years the American Water Works Association has been attempting a cure while disregarding preventive measures. It has also been straining at gnats and swallowing camels. It has attempted to instruct the man who sought instruction but has done not a single thing to keep such a man in the business, and not a single thing to keep unfit men from crowding out the competent men. That, we think, is why so few men, comparatively, have joined it.

The American Water Works Association owes a duty to the public—it must declare a holy war of extermination on the political foundlings and pensioners who are managing so many of our water utilities. It must begin and carry on a vigorous campaign to educate the public that our complex modern water utilities require the constant attention of competent operators. Let the Association take such a stand and carry on such a propaganda and there is little doubt that it will find its membership and influence growing very rapidly. Such a plan of action will bring added responsibilities and some trouble, but it is worth a trial.

COMPOSITE UBIQUITY.

The editor is not ubiquitous; neither is he omniscient nor omnispective. This is unfortunate but not discouraging for a man possessing these attributes might pass up the editor's job as being a bit too light. Many times we think of what a superexcellent journal we could make if we had the remarkable faculties enumerated. Since the editor cannot be at all places at the same time, since he lacks universal knowledge and since he is incapable of seeing all things, he must ask for help.

It would be comparatively easy to fill the pages of a journal such as this with timely matter of the highest quality if the editor only knew what each member of the profession was doing and if the individual engineer would do his part in reporting his activities. We believe this condition can be approximated.

Occasionally we get a letter from an engineer enclosing an account of some work he is just completing, accompanied with the modest statement that it may be of interest to us and to our readers. Such communications are highly appreciated. Almost always they are considered worthy of publication and when published are well received by our readers. When the perfect engineering journal is made it will be reared on this practice as a foundation. In our progress toward perfection may we not ask more of this kind of co-operation from our readers?

ENGINEERING EXPERTS AND ENGINEERING JOURNALS.

One function of the engineering journal is to transmit the newly acquired knowledge of the engineering expert to the engineering profession as a whole. This is a most important function. Whether it is done adequately or not depends primarily on the attitude of the expert, and secondarily on the attitude of the individual practitioner. The former must be willing to give knowledge and the latter must be willing to receive it. The engineering journal is not only willing, but is anxious to do its part. If it appears to fail at times, the failure must be charged to the unwillingness of engineers to give and to receive knowledge. Some hoard knowledge; others are standing pat on what they know—counting themselves to have apprehended.

In the performance of this function it is obvious that the engineering journal both follows and leads engineers; it follows the expert and leads the profession as a whole. We are here using the word expert to denote one who "pushes outward the bounds of human knowledge." Usually, because of an advantageous combining of opportunities and facilities the one who adds to the general fund of knowledge is one who already is prominent in the profession. For this reason the names of a few men appear frequently in the engineering journals. On the other hand, new ideas are constantly coming from engineers who are not widely known. Such ideas, when reported to the engineering journals, are promptly relayed to the profession. The obscure expert oftentimes fails to secure recognition because he does not know how to secure or does not desire publicity.

We have stated that the engineering journal follows the expert. How, then, can it be of service to him? It is of service to him because, though he be the expert today, tomorrow he is looking on while somebody else is doing the experting.

Also we have stated that the names of a few men appear so frequently in the same journal that they attract attention. A city engineer complained, in a letter to the editor, that the journals were altogether too busy advancing the interests of a comparatively small group of prominent engineers. He made this charge because he had not thought of some of the things brought out in this editorial. Let it be clearly understood that if a man's name appear frequently it is because he is doing something and is willing that other people should know it.

There is another reason why prominent engineers get considerable publicity in engineering papers. It is a very simple reason, but one of the best imaginable: they answer letters. It is seldom that a prominent engineer fails to acknowledge an editor's letter and he generally gives the information desired. The engineer who is not widely known generally lays the cold hand of death on the editor's letter. It must be apparent to the least discerning that it is difficult, if not impossible, to give publicity to a man's work when he refuses to answer reasonable requests for information concerning it.

EDITORIAL PARAGRAPHS.

Engineers have prided themselves upon expressing opinion cautiously. They have demanded all the facts before speaking. On questions of public works policy they keep silent because they lack all the facts. Wanting the facts equally, the merchant or the lawyer speaks out and is listened to though his training for giving expert opinion is far less proficient than that of the engineer. But while the merchant or the lawyer knows much less of public works than does the engineer he knows one thing of which, seemingly, the engineer is ignorant. This thing is that knowledge without expression does not lead far. A man does not constitute himself a responsible part of the community by simply knowing things.

The real utility of the expert exists when all the facts are not known. Then the man who is trained in engineering connected with government and is capable of generalization and deduction—the expert—can aid greatly in arriving at sound decisions. When all the facts are determined the prescience of the expert is least needed. Cuvier having a single bone, could, it has been said, reconstruct the entire skeleton. His was the expert's knowledge. With all the skeleton's bones at hand, Cuvier's knowledge was, for the purpose of reconstruction, not greatly necessary. The corner taxidermist would serve about as well.

Are engineers provincial? The spirit of engineering certainly is not so. Why, then, the query? A couple or perhaps three years ago the administration of Philadelphia's public works was contending for the principle that residence was not an important consideration in choosing experts. Several organizations of technical men were asked to endorse this contention and without exception the request was refused. And yet we read somewhere recently the characterization of the engineer as "the man of broad vision and vaulting reach."

Educators draw a definite relation between school attendance and good roads. It is, therefore, with clear purpose that the Illinois State Superintendent of Public Instruction has issued a call to Public School officials to set aside in the schools of the state as good roads day the last Friday in March. To formulate and direct the school exercises on that day a pamphlet outlining various programs and giving other useful data has been distributed. The plan is a useful one and every engineer should in his district use his influence and lend his aid toward its support. To do so is to sow seed for future professional employment.

The geology of the Panama Canal is interestingly discussed in a bulletin issued by the Bureau of Mines. In particular this bulletin discusses the causes and character of the slides at Culebra. Epitomized the facts demonstrated are that the canal banks slid just as the sides of many railway cuts and of other excavations have slid and to stop the sliding exactly the same remedy suffices—flatten the slope until sliding ceases. There is no mystery in the Panama slides. Their magnitude is the only feature that distinguishes them. Failure to anticipate this magnitude was the one great miscalculation in the engineering of the canal, but it was a miscalculation for which very little blame can be attached to the original designers. A thick soil and a thicker jungle covered the ground. As one of the planning engineers remarked to the writer: "We looked into the ground as far as we could but we couldn't see very far."

The luxury of yesterday is the necessity of today. Contemplate these statements of Mr. Geo. W. Cooley, state engineer of Minnesota. "In 1907," says Mr. Cooley, "the Highway Commission distributed about $55,000 for state aid roads and found very little difficulty in satisfying all or nearly all demands. In 1915 the fund was increased to $1,500,000, and the counties, with very few exceptions, thought that their shares were too small." Incidentally, the Highway Commission of this great state serves without pay; indeed, for six years the commissioners have paid their own traveling expenses.

A ditch section on a blue print is a shapely thing. As ordinarily constructed the ditch lacks in all particulars both regularity or neatness of shape. This divergence of the structure from its plan is due to one cause—letting nature slope the sides—and to the bad construction habits which this cause engenders. It can be argued that the drainage ditch as constructed does its work sufficiently well and that to put more construction expense into its making is uneconomic, but it cannot be argued that this ditch is a sightly example of engineering construction. Contrariwise it is ordinarily a blemish on the face of the land; neither the harmony of nature's irregularities nor of the engineer's formal lines is evident—only a raw gash in the green bosom of the earth. If this outburst fails to start something we shall be downcast.

Ballasting railway track by contract is new practice as yet on American railways, but it is growing in favor. Incidentally one railway which perhaps is one that has employed contract ballasting most extensively reports as follows: "The contractor, being financially concerned with the amount of work done, has a more effective interest in increasing the output than our own foremen have, regardless of how capable and conscientious they may be." In this sentence we have expressed the main reason for the economic superiority of the contract method of performing construction work.

ACCOUNTING AND BUSINESS PROCEDURE AS APPLIED TO THE CONSTRUCTION OF LARGE IRRIGATION PROJECTS.

Conrtibuted by Charles E. Bee, Gresham, Ore.

The following article gives a more or less complete description of the general business procedure, with the accompanying forms, suitable to the accounting of a large irrigation or hydro-electric project. All forms and reasonings are the result or outgrowth of experience. The general plan here outlined is that now in use by the United States Reclamation Service on construction work. This has been altered and adapted to meet the requirements and conditions of private work.

Much has been written during the last few years on accounting, efficiency, cost-keeping, etc. Some writers attempt to formulate general principles for all construction work and have succeeded to a greater or less degree. The following explains a system adaptable only under limited conditions, but by slight alterations and adjustments it may be made available in a considerable number of cases.

In order to simplify the explanations, a general organization has been decided on and used throughout the article, Fig. 1. Under some conditions, however, one man may perform the duties of two or more positions, or on the other hand, a position may be divided up between two or more men. Some form of account-numbering should be used—there are several systems that would serve satisfactorily.

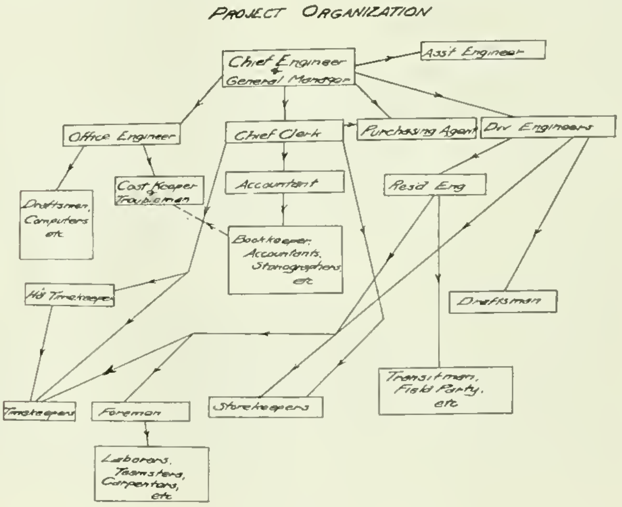


Fig. 1.

In this conjunction great care is necessary in the proper (sane) distribution of the charges. It is a peculiarly difficult proposition to teach this to an organization, even one composed of men interested in their work, and in a general way efficient. Some of the points most often overlooked are: the immediate distribution of the overhead charges, or of charges not directly applicable to the work. Example: An engineer on supervision work would distribute his time over the different parts of the work that he was supervising. Similarly, the time of a camp foreman would be distributed over the different items of his particular job. Secondly, buildings can logically be charged to equipment when built in many cases, a depreciation or rent being charged the work each month. Also camp maintenance charges should be charged or distributed against the work each month, as at that time it is a comparatively simple matter.

Messes, corrals, storehouses, commissaries and material yards are operated in such a manner as to be self-supporting, and as partially explained in the preceding paragraph, all indirect charges are taken up by the work each month. Depreciation charges from equipment are distributed, etc.

All goods used in construction work are classified under three heads: materials, supplies and equipment. Materials include anything taking an appreciable place in the construction. Example: lumber, cement, steel, etc. Supplies include goods used up in such a way as not to retain their individuality. Example: wire, nails, paint, oil, gasoline, etc. Equipment includes machinery, apparatus, etc., used in construction work. Examples: wagons, harness, pumps, hydraulic-jacks, steam shovels, horse-blankets, etc.

Equipment.—A list of the equipment should be kept on cards in the field, as in Fig. 2. These should have a clear description of one piece of equipment on each card. The four columns at the right contain the date, amount of depreciation allowed since previous date, the account that this depreciation is charged to and the value that is left. Each month the depreciations for the different accounts are totaled from the cards and a list sent in to the project office, where the charges to the work and the credits to the equipment accounts will be made accordingly. The project office will also keep a duplicate set of cards of the ones in the field, Fig. 2. At regular or irregular intervals, probably two or three times a year, these will be checked with the cards in the field and the actual equipment, revaluating where necessary.

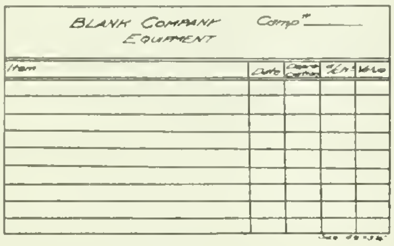


Fig. 2.

Storehouse.—A storehouse is a place where supplies, materials, equipment, etc., are received in quantities and distributed to work as needed, keeping the surplus for all of the work, and not charging it against work until it leaves the storehouse.

Material Yard.—A material yard consists of materials not distributed to work, being a partial storehouse.

It is necessary to keep clearly in mind that a building or place of any kind where supplies, equipment, materials, etc., are gathered, probably under lock and key, may or may not be a storehouse or material yard. Also a pile of lumber standing out in the open may be in a material yard or storehouse, while another pile of lumber alongside of it may be charged up to some work.

Method of Purchasing.

1. **Requisitions on Storekeeper.** Figure 4 shows the form to be used for requisitions on storehouses. These will be made up in four colors, so as readily to distinguish between the copies and to facilitate their proper distribution.

This form is made out by the timekeeper and approved by proper authority. It should have double set of quantity columns, one for amount requested and one for what is furnished, also in place of remarks column, a column for charge account numbers and price column. Original and two copies are sent to the storekeeper, the timekeeper retaining one himself. He indicates the amount furnished in the furnished column, fills out the prices in the price column, and sends one copy back with goods. The original he retains permanently as authority for furnishing goods, and remaining copy he sends in to the project office with his reports.

The reason for some of the above requirements is that in actual practice many requisitions are sent to a storehouse which can only partially be filled. When one such is received by the storekeeper, he ships what he can, marking the quantities in the amount shipped column on all three copies of requisition received by him. Also he makes out a memorandum requisition, original and two copies, covering the unfurnished items on the requisition and temporarily files it. The prices entered will include the storehouse charges.

2. **Requisitions on Purchasing Agent.**—Figure 5 shows the form to be used for requisitions made on purchasing agent. These are made out by the storekeeper and duly approved by the proper authority. The requisition forms should be in tablets already numbered. One copy is retained and one sent to purchasing agent. In ordering, it is not enough to name an article and specify the amount, but a complete description must be given—as, for instance, in the case of machinery parts a dimensioned diagram often saves time and trouble, or in the case of canned fruits one should specify whether gallon or quart tins are wanted. Also an explanation of what the things are needed for and how soon they will be required on the work is essential to economic purchasing. When considerable orders are made of goods in one line, purchases made by competitive bids will, as a rule, effect a large saving. This, however, will take a noticeably longer time than direct purchasing, and in occasional cases the extra cost of buying the whole or part of a large order on the market will prevent delay on the work.

3. **Contracts and Orders.**—Contract orders will here signify orders made from competitive bids under formally executed contracts, while **open market orders** will be requests made by purchasing agent or other authorized person for supplies, materials, etc., which, upon the acceptance and delivery by person receiving the same, constitute informal contracts.

The forms for orders are in two colors, pink for order issued against contracts and green for orders issued on open market purchases. They shall be numbered consecutively as issued. Three copies of this and an original shall be made. The original shall be sent to the vendor and shall contain clear instructions (a) that the number of the order is to be indicated on invoice, (b) that all goods are to be billed at prices agreed and are to include delivery charges to place designated, (c) that invoices in triplicate are to be issued in customary commercial form, one copy being sent to the field headquarters and two to the place where goods are shipped, Fig. 6.

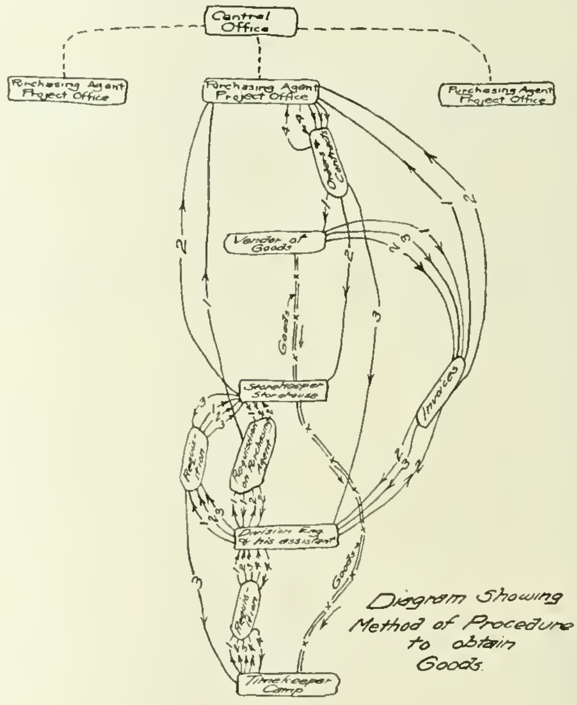

Central Office
Purchasing Agent Project Office
Purchasing Agent Project Office
Purchasing Agent Project Office
Orders & Contracts
Vender of Goods
Goods
Storekeeper Storehouse
Requisition
Requisition on Purchasing Agent
Invoices
Division Eng & his assistant
Requisition
Goods
Timekeeper Camp
1
2
3
4
Diagram Showing Method of Procedure to obtain Goods.

Fig. 3.

4. **Invoices and Memorandum Invoices.**—All invoices shall be considered as a statement of account rendered by a person who has furnished supplies, materials, etc. This will be used as a basis for settlement.

Invoices in triplicate are required—when delivery of staple articles is to be made to any point specified on order, whether contract or open market order and whether all of the articles on a single order are delivered at one time or different times.

Note.—One of the two invoices received by the consignee is to be signed by him with the notation over his signature of the condition of receipt of goods and the account that the goods shall be charged to. This copy shall be mailed to project office.

Memorandum Invoices.—If at any time goods are received without invoices, the person receiving the goods

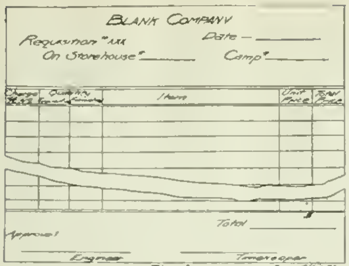


Fig. 4

BLANK COMPANY
Requisition # AAA Date —
On Storehouse # Camp #

Charge A/C No.	Quantity Required	Quantity Furnished	Item	Unit Price	Total Price

Total $
Approval
Engineer Timekeeper
Size 5¼" × 8"

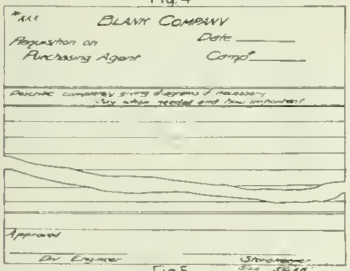


Fig 5

#AAA BLANK COMPANY
Requisition on Purchasing Agent Date
Camp #
Describe completely, giving diagrams if necessary. Say when needed and how important
Approved
Div. Engineer Storekeeper
Size 5¼" × 8"

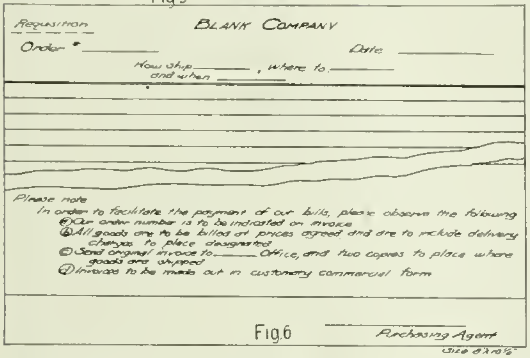


Fig 6

Requisition BLANK COMPANY
Order # Date
How ship and when , where to
Please note
In order to facilitate the payment of our bills, please observe the following
Ⓐ Our order number is to be indicated on invoice
Ⓑ All goods are to be billed at prices agreed and are to include delivery charges to place designated
Ⓒ Send original invoice to ____ Office, and two copies to place where goods are shipped
Ⓓ Invoices to be made out in customary commercial form
Purchasing Agent
Size 8½" × 10½"

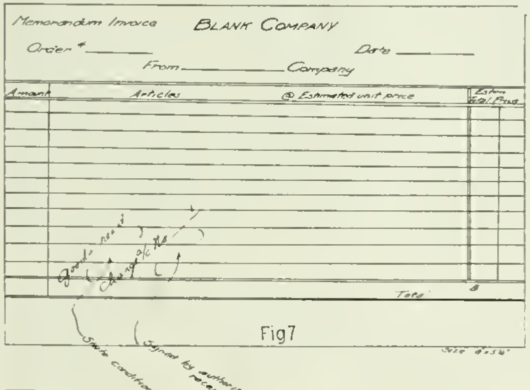


Fig 7

Memorandum Invoice BLANK COMPANY
Order # Date
From Company

Amount	Articles	@ Estimated unit price	Estim. Total Price

Total $
Goods rec'd (State condition)
Charge a/c No. (Signed by authorized receiver)
Size 8" × 5¼"

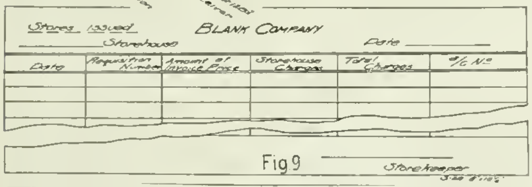


Fig 9

Stores issued BLANK COMPANY
Storehouse Date

Date	Requisition Number	Amount of Invoice Price	Storehouse Charges	Total Charges	A/C No.

Storekeeper
Size 8" × 10½"

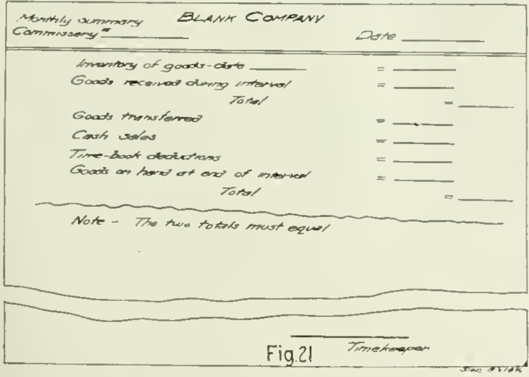


Fig. 21

Monthly summary BLANK COMPANY
Commissary # Date
Inventory of goods-date ____ =
Goods received during interval =
Total =
Goods transferred =
Cash sales =
Time-book deductions =
Goods on hand at end of interval =
Total =
Note — The two totals must equal
Timekeeper
Size 8" × 10½"

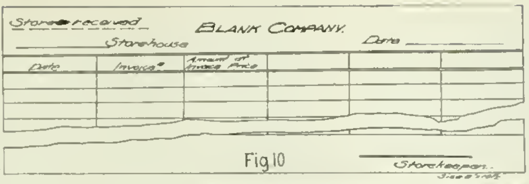


Fig. 10

Stores received BLANK COMPANY.
Storehouse Date

Date	Invoice #	Amount of Invoice Price			

Storekeeper.
Size 8" × 10½"

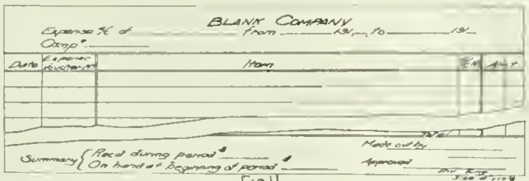


Fig. 11

BLANK COMPANY
Expense % of ____ from ____ 191_ to ____ 191_
Camp #

Date	Expense Voucher No.	Item	%	Amt.

Total
Summary { Rec'd during period $ / On hand at beginning of period $
Made out by
Approved Div. Eng.
Size 8" × 10½"

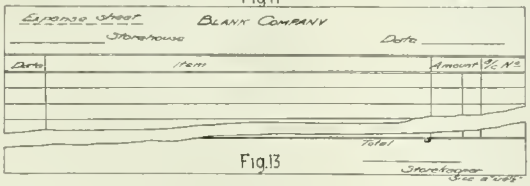


Fig. 13

Expense sheet BLANK COMPANY
Storehouse Date

Date	Item	Amount	A/C No.

Total $
Storekeeper
Size 8" × 10½"

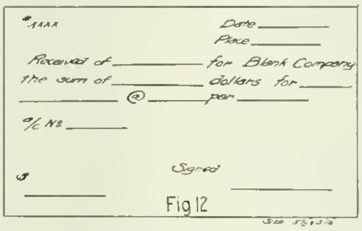


Fig 12

#AAAA Date
Place
Received of ____ for Blank Company
the sum of ____ dollars for ____
____ @ ____ per ____
A/C No. ____
$ ____ Signed ____
Size 5½" × 3¼"

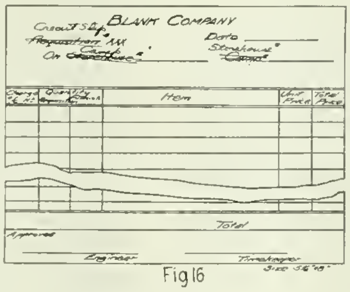


Fig 16

~~Requisition~~ Credit Slip. BLANK COMPANY
AAA Date
On ~~Storehouse~~ Camp # ~~Camp~~ Storehouse #

Charge A/C No.	Quantity Required	Quantity Furnished	Item	Unit Price	Total Price

Total
Approved
Engineer Timekeeper
Size 5¼" × 8"

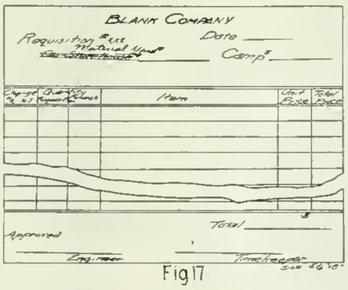


Fig 17

BLANK COMPANY
Requisition # AAA Date
~~On Storehouse~~ Material Yard # Camp #

Charge A/C No.	Quantity Required	Quantity Furnished	Item	Unit Price	Total Price

Total $
Approved
Engineer Timekeeper
Size 5¼" × 8"

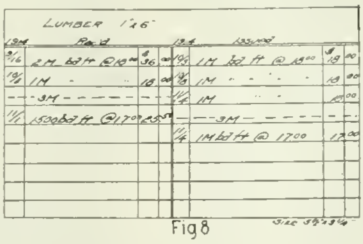


Fig 8

LUMBER 1" × 6"

1914	Rec'd	$		1914	Issued	$	
9/16	2M bd ft @ 18.00	36	00	10/5	1M bd ft @ 18.00	18	00
10/1	1M " "	18	00	10/8	1M " "	18	00
	--- 3M ---			11/4	1M " "	18	00
11/1	1500 bd ft @ 17.00	25	50		--- 3M ---		
				11/4	1M bd ft @ 17.00	17	00

Size 5½" × 3¼"

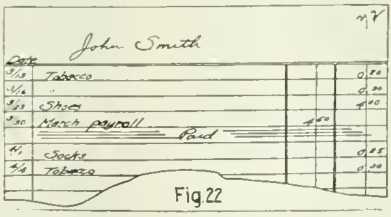


Fig. 22

M.Y.

John Smith

Date				
3/13	Tobacco			0.50
3/16	"			0.30
3/23	Shoes			4.00
3/30	March payroll	4.50		
	Paid			
4/1	Socks			0.25
4/4	Tobacco			0.30

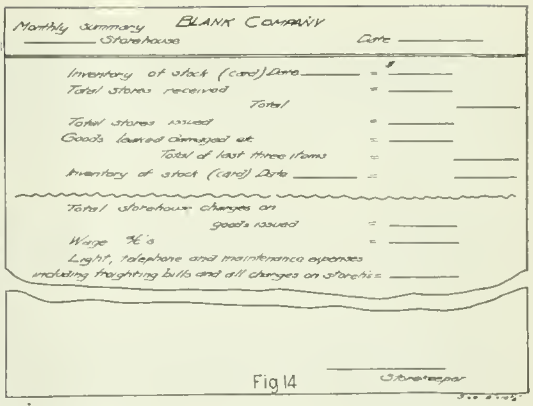


Fig 14

Monthly summary BLANK COMPANY
Storehouse Date
Inventory of stock (card) Date ____ = $
Total stores received =
Total
Total stores issued =
Goods leaked damaged etc. =
Total of last three items =
Inventory of stock (card) Date ____ =
Total storehouse charges on goods issued =
Wage %'s =
Light, telephone and maintenance expenses including freighting bills and all charges on storehse =
Storekeeper
Size 8" × 10½"

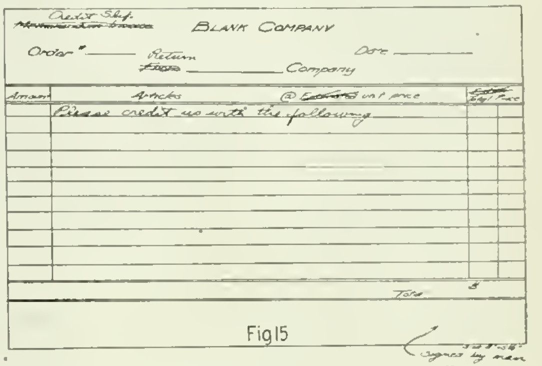


Fig 15

Credit Slip. ~~Memorandum Invoice~~ BLANK COMPANY
Order # Date
Return ~~From~~ Company

Amount	Articles	@ ~~Estimated~~ unit price	~~Estim.~~ Total Price
	Please credit us with the following		

Total $
Signed by man claiming goods
Size 8" × 5¼"

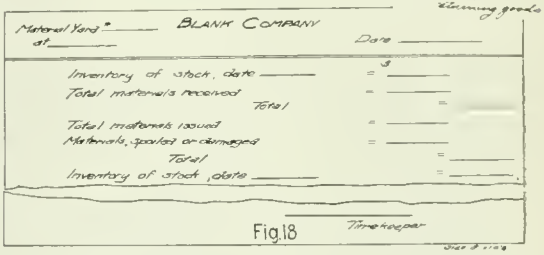


Fig. 18

Material Yard # BLANK COMPANY
at Date
Inventory of stock, date ____ = $
Total materials received =
Total =
Total materials issued =
Materials, spoiled or damaged =
Total =
Inventory of stock, date ____ =
Timekeeper
Size 8" × 10½"

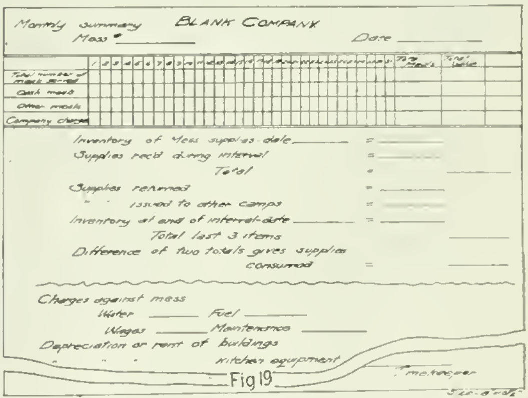


Fig 19

Monthly summary BLANK COMPANY
Mess # Date

	1	2	3	4	5	6	7	8	9	10	…	31	Total Meals	Total Value
Total number of meals served														
Cash meals														
Other meals														
Company charges														

Inventory of Mess supplies-date ____ =
Supplies rec'd during interval =
Total =
Supplies returned =
" " issued to other camps =
Inventory at end of interval-date ____ =
Total last 3 items
Difference of two totals gives supplies consumed =
Charges against mess
Water ____ Fuel ____
Wages ____ Maintenance ____
Depreciation or rent of buildings
" " " kitchen equipment
Timekeeper
Size 8" × 10½"

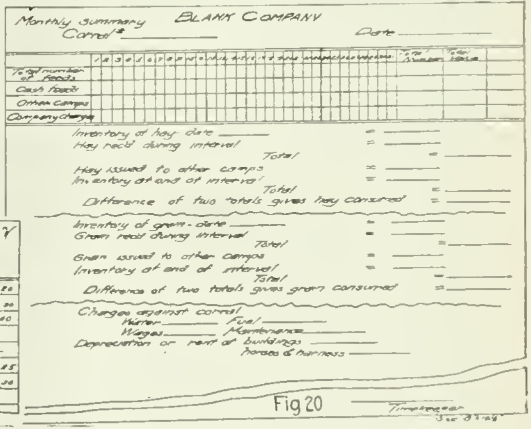


Fig 20

Monthly summary BLANK COMPANY
Corral # Date

	1	2	3	4	5	6	7	8	9	10	…	31	Total Number	Total Value
Total number of feeds														
Cash feeds														
Other camps														
Company charges														

Inventory of hay-date ____ =
Hay rec'd during interval =
Total =
Hay issued to other camps =
Inventory at end of interval =
Total =
Difference of two totals gives hay consumed =
Inventory of grain-date ____ =
Grain rec'd during interval =
Total =
Grain issued to other camps =
Inventory at end of interval =
Total =
Difference of two totals gives grain consumed =
Charges against corral
Water ____ Fuel ____
Wages ____ Maintenance ____
Depreciation or rent of buildings ____
horses & harness ____
Timekeeper
Size 8" × 10½"

Figs 4 to 22.

must make out triplicate memorandum invoices and forward same in place of invoices, Fig. 7. These will be treated in same manner as vendor's invoices until the vendor's invoices shall have been received, when they will be filed together as part of the record.

Storehouse Records.

1. Supply and Material Cards.—This record shall be kept on double entry cards, using in all cases for values the invoice price, a separate card being used for each thing, Fig. 8. Goods received will be entered on these cards before copy retained of invoice or memorandum invoice is filed. In the same manner, amount of goods issued shall be entered in right hand column, corresponding with requisitions received, using, however, in each case the invoice price of goods.

At any time the purchase cost of all the goods in storehouse may be obtained by balancing the cards.

At intervals of from one to three months the card stock record must be checked by inventorying the actual stock, and as a check at least twice a year some one from the project office should at least partially check the goods and stock cards.

At the end of the month the following forms should be sent to the project office. During the month they can in most cases be partially filled out from time to time, as under any circumstances a storekeeper will be busiest about the end of the month, and everything possible should be done to lighten his work at that time. Furthermore, regular tabulated forms insure or at any rate makes possible uniform and adequate reports.

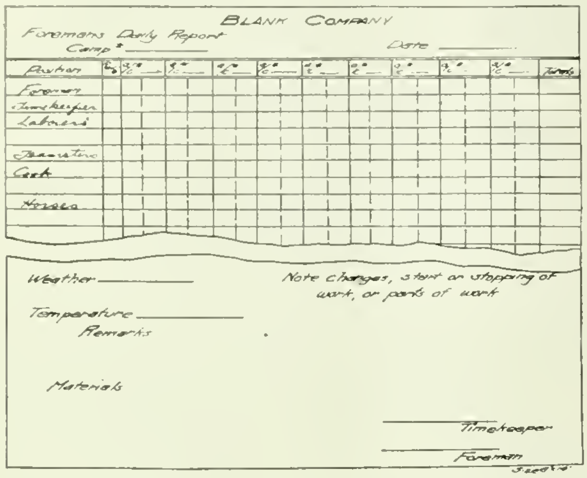


Fig. 23.

2. **Summary of Stores Issued.**—This shall be filled out each month from the requisitions as issued by the storekeeper, one copy going to the project office and one being retained by storekeeper, Fig. 9.

3. **Summary of Stores Received.**—Similarly to the preceding form, this shall be filled out each month from the invoices as received by the storekeeper, one copy going to the project office and one being retained by the storekeeper, Fig. 10.

4. **Petty Cash Report.**—Small bills or purchases that do not exceed $15 or so per month from one man or firm can usually be most conveniently settled immediately by cash. A sum of $100 to $500 can be set aside for this purpose. At the end of the month and possibly once in the middle of the month these reports should be made out, one being sent in to the field office and copy being retained by storekeeper, Fig. 11.

5. **Expense Vouchers.**—A great many small expenses are incurred on all parts of large construction work where, the amount being small, it is often necessary or at least more convenient to pay cash. These may be handled in one or two ways, though the second method is generally the most satisfactory. (a) By supplying one man at each camp—usually the timekeeper—with an expense account. This, however, is almost invariably a continuous source of annoyance, as timekeepers are as a rule low-paid men, and cases have often come to notice of them closing out their accounts under supervision, apparently satisfactorily, later outstanding checks coming in which were unrecorded. (b) By men in authority, as the division and resident engineers, drawing under receipt sums from the storekeepers and advancing small sums in turn to the timekeepers in return for either a receipt or signed expense vouchers. These the engineer turns over to the storekeeper, cancelling the receipt, the storekeeper sending in these expense vouchers along with his own.

These vouchers shall be filled out and signed by the person from whom purchase is made in all cases where cash is paid out, and shall cover all cases entered in petty cash reports, except for railway fares and except in cases such as telephoning, where a similar receipt voucher is obtained, Fig. 12. Expense vouchers properly signed shall be attached to petty cash reports covering all items mentioned thereon.

6. **Storehouse Expense Sheet.**—All expenses not handled by the petty cash fund, and labor expenses which will be handled by the payroll, shall be taken care of by voucher checks issued from project office. Bills shall be sent in from storehouse once a month or oftener. At the end of the month a storehouse expense sheet shall be sent in giving a summary of all bills for the month, one copy being retained by the storekeeper and the original copy sent to project office, Fig. 13.

7. **Monthly Summary from Storehouse.**—The upper part of the form in Fig. 14 will give a check on general accounts of storehouse and prevent stock cards being far out from actual condition. This should usually be used for monthly reports.

The remaining items give the necessary information so that at any time the financial condition of the storehouse can be easily determined.

The Handling of Unsatisfactory or Damaged Goods.

In case goods are received at camps in damaged condition, or goods are of a type not suited to the requirements of the work, or they are not needed, they should be returned to the storehouse, or at any rate credit should be obtained from that place, as the storehouse should be responsible for its unsatisfactory or damaged goods. In the same way, often unsatisfactory or damaged goods can be returned by the storehouse to the place from where purchased. Goods should be returned by the storekeeper only after taking the matter up with division engineer and purchasing agent, and only when the purchasing agent has made satisfactory arrangements and says to go ahead. The unsatisfactory goods will have to be returned by the storekeeper usually, except in cases where an agent or member of the company from whom the goods were purchased is able to examine them. In any case, credit for this will be obtained by using form Fig. 15. By crossing out some of the wording and inserting other, this form will work satisfactorily, and as it is only occasionally used, will prevent duplication of forms. One copy should be retained by the storekeeper, one sent to the project office, and the original should be sent to the place to which the goods are returned.

Similarly, with regard to returning spoiled, damaged or unneeded goods from the field to the storehouse, the form shown in Fig. 16 is used, the original going to the storehouse, one copy going to the project office, and one being retained at place from which goods are returned, and as in the former case, some of the wording will be crossed out and other inserted.

Material Yards.

In theory, whenever goods leave a storehouse, they may be charged direct against the purpose for which they are to be used. In actual practice, this works satisfactorily in most instances. However, there are quite frequently cases when it is not practicable to do this. For example, lumber may be freighted to a large camp to be used on two or three different structures which are being built by the camp, or again, powder and dynamite may be shipped direct from the cars to the work to be stored in a central magazine and used at different parts of the work as the emergencies arise, as when hardpan is encountered in excavation, or perhaps in the case of heavy frost. In such cases a material yard account is used, the goods being charged to this from the storehouse in the same manner as when charging direct, and then as needed goods are issued to the work from the material yard on requisition.

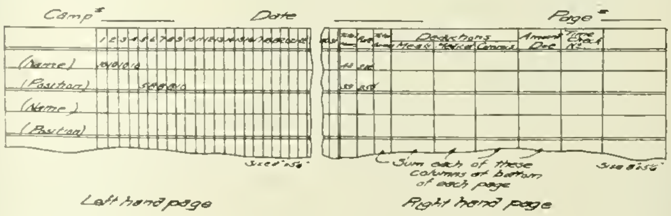
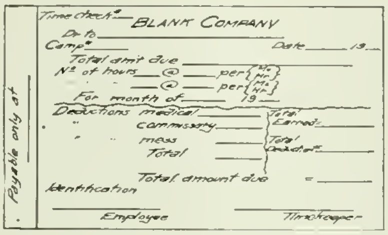


Fig. 24.

Unless the timekeepers are carefully instructed and supervised, material yard accounts will be opened when unnecessary, which in that case will practically cause a duplicating of accounting work. A material yard is handled by the timekeeper at the camp where located. The goods are ordered for it in the same manner by requisition Fig. 4 as for the direct work accounts, the account number in this case being simply material yard number —. Also in requisitioning from it, the same requisition Fig. 4 is used, the word storehouse being crossed out at the top and the word material yard with its number being substituted in its place, see Fig. 17. The same number of copies of the requisition are used, the men in charge of the material yard handling them in exactly the same manner. As a rule, approval by the authorized engineer should be required, but more elasticity allowed, and goods furnished on properly made out requisitions without approval, if an emergency reason is stated.

Small items can usually be charged direct to the work without trouble. For example, on the usual field work picks and shovels may be charged against excavation, and it is not hard to foresee what a few spare implements in a camp will probably be used for and to make charge accordingly. Again, ⅝-in. rope may be ordered so as to have enough to replace worn out halters and tent guys, and so can be charged against its probable use. The amount of surplus goods and supplies at a camp should be kept as small as possible, as by keeping the most of this at a central point (storehouse), it is always available when wanted, and the necessary idle supply on hand is largely reduced.



Payable only at ____

Time checkº ____ BLANK COMPANY
Dr to ____
Campº ____ Date ____ 19__
Total amt due ____
Nº of hours ____ @ ____ per {Mo. Hr.}
" " ____ @ ____ per {Mo. Hr.}
For month of ____ 19__
Deductions medical ____ Total Earned ____
" commissary ____
" " mess ____ Total Deductˢ ____
Total ____
Total amount due = ____
Identification
____ Employee
____ Timekeeper

Fig. 25.

As a rule, storehouses should be built at positions suitable for distributing points, as at end of spur track, at station on main line of railway, etc. About the only condition when a storehouse is needed for a single camp is when only one camp is being operated on the work and the camp is large and at a fixed place. Even under these circumstances there is considerable question but what it would be better not to have a storehouse.

Under usual circumstances a storehouse is located at a camp only when the camp is on a railroad line, the storehouse being built at one camp to serve the camps throughout a district. A storehouse should never be used for a single camp, even though the camp is large and located far from the supply points. When the goods are to be used at a camp, even at a time more or less distant, they can be charged in many cases to the account that they will be used for. This will leave only a few things not possible to charge out with reasonable accuracy, and even these may often be entered against account numbers. Such things as lumber, steel, cement, etc., are frequently impossible of charging direct to the accounts on which they will be used, and so it is necessary to carry them through an intermediate account, yet as there is but one camp where everything will be used, though probably on several different things, it is not a good plan to handle any more things than absolutely essential by the double method. A material yard is practically a storehouse in a limited way, but, owing to the few accounts handled and the resulting simplicity of operation, it is used for such cases.

A storehouse serves its true function when it is the central source of supplies for more than one camp. Where there is only a single camp required for the project, or camps are so widely separated that transportation between them would be unprofitable, a limited storehouse or material yard is advisable. By this method most goods may be charged directly to the subdivisions of the work and the number of items, as in a storehouse, kept at a minimum. This eliminates in most cases the intermediate records kept at a storehouse, and the few that are still necessary can be handled by the timekeeper, Fig. 18.

Messes.

The messes are usually most satisfactory when operated by the company doing the work, as when handled separately by persons only interested in making money, little attention is given to the kind of meals served. As a rule, in order to obtain the best type of men and maintain the most efficient service, messes should be so run as not to make any profit, and in many cases it is well to operate at a loss. A good general rule to follow is to allow this, but in case of losses on mess, not to let them exceed the profits on commissaries. A company operating its own messes should look at it in this light, although practically all companies do not.

Mess supplies, kitchen equipment, etc., are ordered for the mess by requisition on storekeeper, as in Fig. 4, made out by timekeeper. Fig. 19 shows a form for the monthly reports. The upper part can be filled in each day and the lower part at the end of the month. As a rule, except in the case of very large camps, the timekeeper will keep the records of the mess. In the case of very large camps, it may pay to detail a special man (steward) for this work. This, however, is only in exceptional cases.

Small supplies, such as matches, soap, etc., are not strictly mess supplies, but when used in connection with the mess should be included under that head. New dishes, etc., should be charged against kitchen equipment, while, on the other hand, any repair part will be charged against supplies or maintenance. The maintenance shall be charged against the operation of the mess. Again, coal, whether used for heating or cooking purposes, and such things as soap, matches, etc., if used in connection with either the cook house or dining room, will be charged against the mess.

Corrals.

The general methods and forms used in handling the accounts of the corral are similar to those used in handling the mess. Horses are charged so much a day to cover feed and the other items connected with the corral. The amount will depend on the location of the camp, but will usually be between 50 and 75 cts. a day and is adjusted so that on an average neither profit or loss occurs. Corral supplies, etc., are ordered for the corral by requisition on the storekeeper, as Fig. 4, made out by the timekeeper. Fig. 10 shows a form for the monthly report. The upper part can be filled in each day and the lower part at the end of month, as in the case of the monthly mess reports. This will be done by the timekeeper. The amount and cost of consumption of hay and grain will be kept separate. Also one item appears which did not occur in the case of the mess and is a little troublesome,—the depreciation on the horses. However, by revaluating once or twice a year, this can be adjusted.

In order to understand this method of handling a corral account, one must remember that by all economic theory the work performed by either horses or human beings is of a value sufficient to feed, clothe, house, and usually in the case of the human being but not that of the horse, to furnish also more or less excess or luxuries. So the horses are placed on the payroll for an amount sufficient to cover the above cost and to pay a reasonable interest on their money value, as well as depreciation. Each day all horses attached to a camp are charged to items of the work, even if the horses should be idle. Example: If some horses haul a load of hay, the horses' time is charged against the corral and is part of the corral expense. However, if one ton of the hay is used by the men in the camp to put in their bunks, part of the horses' time will then be charged against camp maintenance instead of corral. Again, in order to cut down indirect charging, it is best not to allow any horses at active camps to be charged to idle time. A central camp or some place can be arranged at which to place excess, or stock in poor condition.

Finally, a corral is operated in the same manner as a mess,—an amount being credited to it from the horses sufficient to pay all expenses. The horses in turn go on the payroll for a similar amount, the total value of feeds as shown at the top of the monthly report being the gross receipts for the month in question.

Commissary.

Commissaries should be handled by the timekeeper. Even in very large camps this will prove most satisfactory, as by this arrangement, in most cases, two or three men (timekeeper and assistants) will be in commissary during the few hours open to the men for the supplying of their needs. Secondly, it is essential that the person who looks after the handling of such goods should be familiar with the men and keep informed as to the amount that can be advanced in any case without danger of loss to the company.

The commissary goods shall be requisitioned from the storehouse in the same manner as in requisitioning goods for any other part of the work, as in form shown in Fig. 4. A complete list of all goods kept in commissaries shall be posted in each showing the selling unit price of each article. This prevents petty graft on the part of any timekeeper who is not absolutely honest and also enables the men to see what they are paying. At the end of each month, a physical inventory of goods shall be taken by the timekeeper and a monthly report, as in Fig. 21, turned in. The amount of cash as shown by cash sales shall accompany the report. Requisitions will cover goods transferred, and the total commissary deductions against the men in the timebook will give timebook deductions. A timekeeper should be held responsible, being bonded by company if necessary, for the absolutely correct balancing of accounts. A loose leaf book, as in Fig. 22, is very satisfactory for this. When account is paid by payroll, a heavy line is drawn across page, the amount credited, and the account practically starts over again, exactly as when paid by cash.

In case of machine shop, saw mill or any separate account being advisable, it may be handled in a similar manner as in the preceding cases, all material, labor, rent, depreciation, etc., being charged against and the products being credited to it.

Daily Reports From Work.

Each day the timekeeper shall make out a report as in Fig. 23, of which, when approved by the foreman, one copy shall be turned into the division engineer's office and one shall be retained on file by timekeeper for reference in making out weekly or monthly cost reports. This shall show in the main part of the report the distribution of the labor arranged according to rates. Space is left at the bottom to report all items of importance connected with the work, taking the place of the diary, which is often required. As regards the diary record, the one possible trouble with this method is very slight—the danger of an incomplete record through lost sheets. The advantages gained more than offset this—immediate supervision over the timekeeper, thereby eliminating the carelessly written report and the several reports written at one time through laziness.

Payroll.

The payrolls are made up by the timekeeper and signed by him and approved by the foreman. Then they are turned over to the division engineer, who, by signing them, vouches, to the best of his knowledge, regarding their correctness. Fig. 24 shows the form used, the left hand side of the figure represents the back of one page and the right hand side shows the front of the next. In computing the time of monthly men, this shall, in all cases, be figured on the basis of a 30-day month, even though the month has 31 or 28 days in it. This method has proved satisfactory in practice, and though the approximation works against the company as a whole, sufficient advantage is gained in return from standardizing of fractional rates and the resultant minimizing of mistakes of the timekeepers. Two horizontal columns are given to the time of each man. At the beginning of a month, his rate and hours are kept in the first of the columns. If at any time during the month his rate is changed, the new rate is placed in the second horizontal column and the hours continued there. If a third rate is given to the man, the only satisfactory method is to proceed to another page in the book and open a new account, a time check being issued from the first account. Fig. 25 shows the form used for time checks.

In case a man is transferred from one part of the work to another, so coming under a new timekeeper, a time check is issued and given to the man for his full time. Arriving at his new camp, he gives this to the timekeeper, who enters him on his timebook, attaching the time check to the same page, so that when timebook is sent into the project office at the end of the month the whole necessary data required as a record for paying the man shall be grouped together. If the man loses his job, a time check is made out, which he takes to the nearest place where there are arrangements for paying, usually a storehouse. The storekeeper has an especial account in the local bank for cashing these checks. He takes over the time check and makes out a check on his account in place of it. When a man is paid by the payroll, his time simply goes in to the project office at the end of the month on the timebook. The project office issues checks for all amounts in the Amount Due column, which have not been paid, as shown by the time check No. column at the right. These checks signed by two men are sent to the field at or before a certain stated date each month. The checks are made payable on the same account as the time checks, but without requiring them to pass through the storekeeper.

SOME FEATURES OF AN AERIAL CABLEWAY OVER THE WHIRLPOOL AT NIAGARA FALLS, ONTARIO.

An aerial cableway is being built across the Whirlpool at Niagara Falls, Ont., which will have a capacity of 46 passengers—24 seated, 21 standing, and the conductor. The Torres system of constant tension multiple cables is used, and the design is based upon Spanish patents. The cost of the project, which is about $60,000, was provided by Spanish capital.

The passenger car is suspended from a running gear which travels on six parallel cables. The car is 10 ft. 10 in. wide, 24 ft. long and 23 ft. high. The weight of the car empty is 3½ tons and fully loaded 7 tons.

The terminals are at Thompson's Point and Colt's Point, 1,705 ft. apart, the former being 249.5 ft. above the river and the latter 246.5 ft. The track cables are 1-in. crucible steel, made of 7 round strands surrounded by 16 locked coil strands. The sag of the track cables unloaded is 47.6 ft., and the maximum when loaded with car and passengers is 100.1 ft. At Colt's Point the track cables are rigidly anchored into the cliff, but at Thompson's Point each track cable passes over a grooved sheave and is fastened to a 10-ton counterweight. These counterweights move up and down freely in steel guides. It is thus apparent that a uniform tension of 10 tons is placed in each cable, this tension being independent of the car and its load. Each cable is an independent unit, and should any one of the cables break the others would support the car without any increase in stress in them. The strength of each track cable is about 92,000, which gives a factor of safety of 4.6.

The car is propelled by a ⅞-in. cable, one end of which is attached to the car; the other end passes over a sheave at Colt's Point, passes back across the Whirlpool, then over a sheave at Thompson's Point, and then to the driving sheave. From the latter the cable passes around three sheaves, to one of which there is fastened a 10-ton counterweight, in guides; this creates a tension in the cable which adjusts any slack caused by the rising and falling of the car. After passing around another groove in the driving sheave the traction cable passes out to the other end of the car. The 8-ft. driving sheave is operated by a 75-HP. motor, which gives to the car a maximum speed of about 400 ft. per minute.—Extracts from article in The Canadian Engineer.

RELATION BETWEEN THE PROPERTIES OF HARDNESS AND TOUGHNESS OF ROAD-BUILDING ROCK.*

By Prévost Hubbard, Chemical Engineer, and F. H. Jackson, Jr., Assistant Testing Engineer, Office of Public Roads and Rural Engineering.

Since the establishment of the Road-Material Laboratory by the United States Government, upwards of 3,000 samples, representing every known variety of road-building rock, and obtained from every State in the Union, as well as from foreign countries, have been subjected to the hardness tests by the Dorry method and to toughness tests by the Page Impact method and the results plotted. A study of the results shows:

(1) That the average toughness for all tests made is about 9.

(2) That the average hardness increases with toughness, and that the rate of increase becomes less as the toughness values become larger.

(3) That individual values of hardness vary through wide limits for low values of toughness, and that the variations from the average decrease uniformly with the increase in toughness up to a certain point, about 20, after which they remain constant with very little variation from the average.

(4) That, when any given value for toughness falls within certain limits, which define the suitability of the material for macadam-road construction under different traffic conditions, the corresponding value for hardness will fall within similar limits for hardness.

Finally, the results of 2,500 individual routine tests made by the Office of Public Roads and Rural Engineering show that for practical routine work the hardness test adds nothing to our knowledge of the value of any particular rock sample for use in water-bound macadam-road construction over that obtained from the toughness test.

While the binding or cementing value of a rock is a most important consideration from the standpoint of ordinary macadam construction, the same is not true of broken-stone roads which are surface treated or constructed with an adhesive bituminous material. The hardness of the rock is also of relatively less importance, owing to the fact that the fine mineral particles produced by the abrasion of traffic combine or should combine with the bituminous material to form a mastic which is held in place and protects the underlying rock from abrasion so long as by proper maintenance it is kept intact. The toughness of the rock, however, is of more importance, as the shock of impact is to a considerable extent transmitted through the seal coat and may cause the underlying fragments to shatter. It would therefore seem that the minimum toughness of a rock for use in the construction of a bituminous broken-stone road or a broken-stone road with a bituminous-mat surface should for light traffic be no less than for ordinary macadam subjected to the same class of traffic. For moderate and heavy traffic, however, the same minimum toughness may probably prove sufficient, owing to the cushioning effect of the bituminous matrix. No maximum limit of toughness need, however, be considered for any traffic.

In the case of bituminous concrete roads, where the broken stone and bituminous material are mixed prior to laying and consolidation, it would perhaps appear advisable to set a minimum toughness of 6 or 7 for light-traffic roads instead of 5, in order to insure against the possibility of the fragments of rock which have been coated with bitumen being fractured under the roller during consolidation, and of 12 or 13 for moderate and heavy traffic, instead of 10 and 19, as in the case of water-bound macadam roads.

For broken-stone roads which are to be maintained with dust palliatives, it would appear that the same limits of toughness should hold as for ordinary macadam.

For easy reference the following limits of toughness are given in Table I, as representing facts developed in the foregoing discussion. It is, of course, quite probable that these limits will require modification as the correlation of laboratory tests to service results becomes more perfect.

TABLE 1.—LIMITS FOR TOUGHNESS FOR ROCK USED IN THE CONSTRUCTION OF BROKEN-STONE ROADS.

Type of road.	Light traffic.		Moderate traffic.		Heavy traffic.	
	Minimum.	Maximum.	Minimum.	Maxi. mum.	Minimum.	Maximum.
Macadam .... Macadam with dust palliative...	5	9	10	18	19	..
Macadam with bituminous mat. Bituminous broken stone with seal coat	5	..	10	..	10	..
Bituminous concrete with or without seal coat......................	7	..	13	..	13	..

RAILROAD LOCATION AND CONSTRUCTION THROUGH MUSKEG SWAMP.*

By J. L. Pickles, Chief Engineer, Duluth, Winnipeg & Pacific Railway, West Duluth, Minn.

In locating roads over muskeg country, it is well to have a slight knowledge of the geology and the accepted theory of this formation.

When the continental ice cap receded, it left vast quantities of glacial drift composed of all sorts of material varying in size from huge boulders weighing several hundred tons down to an impalpable powder forming clay. It is owing to this glacial invasion that the surface differs from the normal type in the minor topography and drainage. The whole plateau is deeply covered with glacial deposits, which have disarranged the drainage so that there are abundant lakes, swamps and muskegs. Overlaying the glacial drift and under the swamp is usually found a strata of impervious blue clay. As the ice melted, the materials were deposited as an over-mantel of glacial drift. These were deposited in moranes and in a very irregular manner, so that the topography of the country did not conform to the usual regularity presented by country formed by the errosive action of water. Huge quantities of ice were left imbedded, afterwards melting, which formed large circular depressions or kettles. These became filled with water in form of lakes. The muskeg is of recent formation and is composed of decayed moss and various vegetable growth, which, by constant decay and renewal gradually filled the depressions until we have what is known today as muskeg swamps.

As the sodded formation does not bear the regular contours usually found, it is very necessary in determining locations over these swamps, that a thorough investigation should be made to determine contours of the hard bottom. We are too apt to take it for granted that the muskeg is but of a shallow formation, and trust to our road to be supported by the decayed vegetation than to accept the country surrounding these swamps, which is invariably covered with very thick vegetation. There is a great temptation to run our lines through the open country in order to avoid a more difficult location on higher ground in which the irregularities are apparent. In locations over such swamps, it would be well for the engineer to proceed in the same manner as he would proceed in locating over frozen lakes and not trust the moss covering to support his line until he has thoroughly tested the same and ascertained what the bearing value of the soil is. In testing it will quite often be found that the surface is floating and the lake is not yet filled to the bottom. In such cases disaster is sure to follow unless adequate measures are taken to support the track. Another weakness that is often met with in such locations is the desire to obtain long tangents. It would be much better to introduce curvature in the alignment in order to keep the location over shallow swamps than to produce long tangents crossing over deep pockets. It would, of course, take a great deal of stamina on the part of any engineer to introduce apparent reversed curves on what appears to be level ground; and while this would undoubtedly cause a great deal of criticism of his location, it would in some instances be a very great economy to do so.

---

*Extract from Journal of Agricultural Research, Department of Agriculture, Washington, D. C.

*Paper before Minnesota Engineers' and Surveyors' Society.

I have made a study of the vegetation covering these swamps, with a view to ascertain if the growth was in any way indicative of the depth of the swamp. Generally speaking, it will be found that the smaller the tree growth and the more luxuriant the growth of the moss, the deeper will be the muskeg, but I have not as yet been able to ascertain anything more than a very approximate depth by such observations. The areas found void of tree growth should be regarded with suspicion, as this usually indicates deep and recent formation and quite often indicates floating bog.

It has been found in some of the lines already constructed, that, had soundings been made previous to final locations, a great deal of money would have been saved over what was necessarily spent bringing the road up to the required standard after operation was begun. As a concrete example, take the Miller Trunk Sinkhole on the Duluth, Winnipeg & Pacific Railway. On this road, as on all others, it was necessary for the locating engineer to make a showing of miles per day almost regardless of the results obtained. As constructed, the line at this point was first heavily corduroyed, which broke through before traffic was started. Soundings taken at that time showed a depth of about 60 ft. to apparently hard bottom. About 83,000 cu. yd. of material were required to again bring the track above water. A great deal of time and money was lost, due to the failure of the surface. All of this would have been avoided had adequate soundings been taken during the location, and the money and time lost in this one instance would have been much more than required for adequate soundings of the whole line.

In railroad construction over muskeg swamps there are eight methods in general use, as follows: First. To follow out the usual form of construction, laying the track directly on the surface and afterwards ballasting up to grade. Second. To corduroy or crossway the surface, using long timbers, laying them in alternative layers parallel and transverse to the line, afterward bringing the track to grade with usual ballast. Third. By excavating ditches along the side of the line, using the material excavated to form embankment. Fourth. The use of sawdust, cinders or other light material floating the line over and depending on the buoyancy of the muskeg for support. Fifth. Fill to the bottom with logs and timber. Sixth. Fill with excavated material. Seventh. By bridging. Eighth. Where considerable fill is expected to be carried over the swamp, piles have been driven on about 4-ft. centers and timber grillage constructed on this, and the fill on the timber grillage.

Drainage is often resorted to with very beneficial results. However, in many instances where deep muskeg is encountered, it is not practical to drain due to large lakes in the vicinity and exceptionally heavy expense required due to great length of ditches which it would be necessary to construct. Ditches cut in this formation are prone to close and it is a constant source of expense to keep them open. And then again it will usually be found that there is no place to stop the ditch without carrying it to an unreasonable distance. While such ditches are always more benefit to the surrounding country than to the roads constructing them, they invariably bring on a system of suits in which the company is usually the loser. It is for this reason alone that many of the swamps in the northern part of the state are not drained.

Whatever the construction decided upon, it must be borne in mind that a good foundation must be obtained, otherwise there will be a constant source of expense and trouble from rail running, causing broken rails, derailments and a constant settlement, which will result in very heavy maintenance charges.

In locations over this country, it is well always to keep the grade as near the surface as good drainage will permit, in order not to overload the surface by the weight of heavy embankments, which are apt to break through the surface and some times will cause rupture through the underlying strata into the secondary strata, which is of an older formation but not yet solidified sufficiently to carry the increased load.

Swamps are like wrecks—there are no two of them alike, and they are very good things to avoid if at all possible.

ENGINEERS IN THE CONSTRUCTION FIELD.*

By Frank B. King, Superintendent of Construction, Drumright, Okla.

Positions in the designing and supervising line are hard to get and exceedingly hard to keep, and very few young men can hope to do anything in an independent practice.

In the construction field engineers are few and their need is sorely felt. The competition of the present day has made necessary a departure from the old strong arm methods of construction. Foremen at one time needed but the quality of a slave driver and their whole use was to see that the men made as many motions as possible and were properly cussed out at more or less regular intervals. Now they should not only be able to handle men, but should be able to keep time, make out reports and devise ways to cut down the cost of the work. On jobs in our time the profit is made or lost by the way the job is handled after the work is started.

The writer made the statement in a paper once that no engineer should be entrusted with the design and superintendence of a work unless he were able to organize the forces and give the direction necessary for a complete performance of that work. This statement may be a little strong, but a far too common idea, that engineers are as a rule poor business men and too apt to look at the nicety of a work rather than at the utility of the same, should be dispelled.

Engineers should be taught that they must be able to handle men to make a success in the construction field, and in any field the main line to success is in getting men to do what you want them to at the time you want them to do it.

With men having a knowledge of engineering principles in the position of superintendent and foremen, a much better idea of the desires of the supervising engineer would obtain, a better understanding would be had and the progress and results should be much more satisfactory. Surely the pride of achievement and the satisfaction of reward is as great in this line as in any other.

If contractors could be made to see that men with engineering ability could do all the things that others could, and many of the things that others could not, their organizations would soon be filled with men having this training. On the other hand engineers entering this field must understand that results are the mark of success, that the ability and will to do are essential and that responsibility must be cheerfully assumed and fully met.

Sanitary Survey of Indiana Summer Resorts.—The water department of the Indiana State Board of Health will conduct in the coming summer a sanitary survey of the summer resorts in Indiana. In recent years great numbers of typhoid cases have developed soon after persons returned to their homes from summer vacations. This work will consist of a complete sanitary survey of as many resorts as can be covered. By a complete survey is meant an examination of all water supplies, a study of means of sewage disposal and the sanitary conditions surrounding the cottages and hotels, and the collection of data in reference to the health of resorters in previous years. After this field and laboratory work has been completed, recommendations will be made whereby many of the bad features of the resorts may be corrected.

---

*From a paper before the Oklahoma Society of Engineers.

THE EXPERIENCE OF ELEVEN AMERICAN CITIES WITH CONCRETE IN SEWER CONSTRUCTION.

The following expressions of opinion as to the value of concrete pipe and monolithic concrete in sewer construction is from the paper entitled "Durability of Concrete Pipe," read before the annual meeting of the American Concrete Pipe Association by Mr. J. H. Libberton, Division Engineer, Information Bureau, Universal Portland Cement Co., Chicago.

Wilmington, Del.—(Reported by A. J. Taylor, City Engineer). We have used approximately 10,000 ft. of premolded reinforced concrete pipe varying in size from 24 ins. to 72 ins. The first laid eight years ago has been in constant service and has given perfect satisfaction. Similar results have been realized with the remainder.

Springfield, Mass.—(Reported by Chas. M. Slocum, Deputy City Engineer.) This cement pipe was purchased by the city of a local manufacturer, and owing to the fact that it was bought under no particular specifications or inspection, it proved to be more or less defective, especially the pipe bought during the latter part of our use of the same. About ten years ago we began to use Portland cement concrete for the construction of all sewers in this city greater than 2 ft. in diameter. The use of concrete has been most satisfactory and has resulted in a large saving to the city over and above the cost of sewers formerly constructed of brick. I may add that all sewers at the present time are laid by the city on the day labor plan. We are gradually replacing the old cement pipe sewers laid many years ago with vitrified clay as rapidly as serious defects appear. However, we are firm believers here in Portland cement concrete, and I have no doubt that a very superior pipe sewer can be constructed with this material, with or without proper steel reinforcement. We may further add that all our larger concrete sewers have been laid with plain monolithic concrete and without reinforcement.

Salt Lake City, Utah.—(Reported by Sylvester Q. Cannon, City Engineer.) The first concrete sewer was laid in this city in 1886, 36 ins. to 48 ins. in size and about 7 miles in length. This sewer shows no perceptible deterioration and is in excellent condition. Several years ago an intercepting sewer of reinforced concrete of 30 to 40-in. diameter was built, which has been quite leaky, but this has been due entirely to poor construction. The machine-made concrete pipe has proven to be very satisfactory. Prices here run about the same as vitrified pipe. Compression tests show the concrete pipe to be considerably stronger than vitrified. It is very dense and smooth. At the end of this season the city will have approximately 75 miles of concrete pipe sewers in operation.

Milwaukee, Wis.—(Reported by Ed. F. Leidel, Chief Engineer.) We have approximately 487 miles of sewers in this city, 130 miles of which are 30 ins. to 120 ins. in diameter. During the period from Jan. 1, 1908, to Jan. 1, 1915, the sewer department has relaid a total of 2,700 lin. ft., of which there were 851 lin. ft. of vitrified pipe sewer, 1,070 lin. ft. of cement pipe sewer and 779 lin. ft. of which we have no record as to kind of pipe. This period of seven years is typical of the percentage of pipe relaid in the past 20 years. We have used concrete pipe for over 25 years. Machinery used in this city for the past four years for manufacturing a wet-mix concrete pipe in sizes up to 18 ins. and reinforced concrete pipe 24 ins. to 54 ins., has given, in our opinion, splendid results.

Jackson, Mich.—(Reported by H. S. McGee, Sanitary Engineer.) So far as this department is aware, the concrete pipe sewers have been satisfactory and perform their function efficiently. The accompanying total will indicate the extent which concrete pipe sewers have been constructed in this city. (The total indicates that $210,538 have been spent for concrete, while the total for all sewer construction in the city has been $489,764, or 43 per cent of the expenditures for sewers have been for concrete.)

Green Bay, Wis.—(Reported by August Brauns, City Engineer.) Concrete has been the material used in building the sewers larger than 24 ins. for the last seven years, with the exception of a small amount of brick and vitrified clay sewers. Concrete has given entire satisfaction in every respect and we are thoroughly pleased with it.

Richmond, Ind.—(Reported by Frederic R. Charles, City Civil Engineer.) We have used concrete for sewer construction for a number of years and in general have obtained good results. Of course, you know that concrete can be made good, bad or indifferent and this applies especially to sewer work. With good materials, honest workmanship and careful inspection, there is no doubt in my opinion that concrete sewers will give a full dollar's worth of service for every dollar of cost.

Albany, N. Y.—(Reported by Frank R. Lanagan, City Engineer.) We have used reinforced concrete pipe varying in size from 24 to 60 ins. inside diameter for an intercepting sewer and for trunk sewers with much satisfaction. We originally used the reinforced concrete pipe for the intercepting sewer because its use did not make it necessary to clutter up this street with piles of sand, stone, cement, concrete mixers, etc. We have since used it for trunk sewers because it has been more economical than monolithic concrete.

Janesville, Wis.—(Reported by C. V. Kerch, City Engineer.) In our sanitary sewer system the main outlet sewer extending from the junction of the east and west side systems at the end of the syphon under Rock River to the discharge below the city, a distance of about 1¾ miles, is of 48-in. concrete pipe construction. There is also some 36-in. pipe and about ⅓ of a mile of 24-in. trunk line connections of concrete pipe. This work has been in use since 1908 and to date has proven perfectly satisfactory without repair or attention of any kind.

Savannah, Ga.—(Reported by E. R. Conant, Chief Engineer.) Properly constructed reinforced concrete pipe is especially adaptable to supersaturated soil. I am of the opinion that it stands every necessary test. I do not believe in the use of vitrified clay pipe above a diameter of 24 ins. We have had practically no trouble in the construction of the concrete pipe sewers. They have been laid in very bad bottom. There is practically no seepage in the joint and I do not hesitate in saying that I am a firm believer in the use of this type of material. It should be properly constructed, thoroughly investigated during the construction and carefully laid.

Halifax, Nova Scotia.—(Reported by F. W. W. Doane, City Engineer.) We have been laying concrete sewers for about a quarter of a century. We have never had a failure in this work, though over 20 years ago there was a good deal of public criticism and an investigation was held. With ordinary sewage I feel certain there is no disadvantage in using concrete. Up to the time concrete was adopted, brick sewers were constructed for the larger sizes and as the Labor Unions forced the rate of wages up, we were obliged to adopt concrete construction exclusively and have used no other material in the last 25 years. There are certain acids used in dye work and other industries which, if not sufficiently diluted with water, will affect the concrete, but if the discharge from such buildings empties into a considerable volume of ordinary sewage, I do not think it would have any effect upon the concrete. We have been able to make the concrete sewers as cheap as the smaller sizes of clay pipe and cheaper than the larger sizes. As concrete sewer pipe is now made by machinery, it is considerably cheaper than clay pipe, and being made much more compactly than formerly, is not surpassed by any other material.

Bluefield, W. Va., Adopts Manager Plan.—Bluefield, W. Va., a city of 12,000 inhabitants, is the latest city in that State to adopt the city manager plan of government. The ordinance providing for this plan provides also that the salary of the manager shall be $250 a month.

SOME FEATURES OF THE NEW PLANT OF THE REMINGTON ARMS & AMMUNITION CO. AT BRIDGEPORT, CONN.

The main building of the new plant of the Remington Arms & Ammunition Co., Bridgeport, Conn., contains 1,335,200 sq. ft. of floor space, and is probably the largest factory building ever built. Actual construction was started March 17, 1915, and the building was completed on Nov. 10—less than eight months later.

The entire plant comprises 38 units, and includes a power plant, five forge shops and the main building. The total floor area is 1,538,000 sq. ft., the total window area 350,000 sq. ft., and the plant, equipped, represents an investment of about $12,000,000. The construction of this plant required 11,500 tons of structural steel, 20,000 cu. yd. of concrete, 18,000,000 bricks, and 15,000,000 ft. B. M. of lumber. When in full operation the plant will employ about 18,000 men. The main building consists of thirteen manufacturing units whose axes are perpendicular to the main axis, which passes through the center of the twelve connecting service units. The structure has a total length of 1,991 ft., and is of brick, steel and concrete construction. The service units are 50 ft. 1 in. x 77 ft. 11 in., the machine units are 61 ft. 1 in. x 274 ft. 5 in., and the whole building has a uniform height of five stories.

Adjoining the main building there is a one-story service building of the same dimensions as the others; this leads to the dry kiln, which is a one-story building, 94 x 272 ft. The five forge shops extend in a line beside the main building, between the latter and Lake Pembroke, upon the shore of which is the power plant. Four of the forge shops are 64 x 352 ft. and one story high; the fifth is 64 x 192 ft. and two stories high; the latter contains 12 bays, and each of the former 22 bays. The power plant is 93 x 161 ft. x 50 ft. high.

The floor construction at the ground level consists of 4-in. of tar rock concrete, 1 in. of tar and sand, 3 in. of hemlock underflooring, and 1⅛x3¼-in. maple surfacing. The upper floors are built of 2x8-in. long-leaf yellow pine on edge; two-ply damp-proofing, ⅞x5¼-in. spruce underflooring, and 1⅛x3¼-in. maple surfacing.

The buildings are equipped throughout with sprinklers, fed from two 100,000-gal. tanks located near the power plant. In addition there are installed in the power plant two 1,000-gal.-per-minute pumps. There is also a connection with the city water system. Scattered about the grounds there are 18 three-way hydrants; fourteen of these are provided with shelters containing lines of 2⅝-in. hose. The fire-fighting equipment also includes chemical engines, fire extinguishers, and buckets. For fire alarm purposes the plant is districted, and there are 65 alarm stations.

There is a fire escape at each end of each machine unit of the main building, forming a corner of the structure. These escapes are enclosed wells, and entrance to a balcony at each floor level of them is gained through doors equipped with locks which open at the slightest pressure against a transverse rod placed breast high on the doors.—Extracts from article in The Iron Age.

Roller Conveyors Used in Construction Work.—In erecting a large manufacturing building for the Farrel Machine & Foundry Co., at Ansonia, Conn., the Aberthaw Construction Co., Boston, Mass., has installed a system of gravity roller conveyors of the Matthews type for handling materials on the work. These conveyors consist of steel ball-bearing rollers assembled in steel frames in standard portable units of 4 and 8-ft. lengths. With these conveyors the cement is transferred direct from the car to the stockpile adjacent to the mixer; the bricks are conveyed either to the stock piles or direct to the hoists, and from the latter to the masons; and the mortar is conveyed from the mixer to the hoists and from there to the masons. Although roller conveyors have been used quite generally in the operation of manufacturing buildings, their use on construction work has heretofore not been as extensive as on this work.

SOME DESIGN FEATURES OF THE EDGEWATER BEACH HOTEL BUILDING, CHICAGO, ILL.

(Staff Article.)

The Edgewater Beach Hotel, which is under construction on Sheridan Road, at the foot of Balmoral Ave., Chicago, Ill., is a nine-story reinforced concrete and steel structure of unusual design. The plan of the building has the form of a Greek cross, from the center of which projects a tower thirteen stories high. The building is located between Sheridan Road and Lake Michigan, and the arms of the Greek cross are so oriented as to give the occupants of the various rooms a view of either Sheridan Road or the lake. In the main, the construction is reinforced concrete, although the central tower, which houses the elevator shafts and stairwell, is steel. There are also some steel trusses in two of the wings, these trusses being carried on concrete columns. The concrete columns throughout the building are without the enlarged heads usually found in flat slab construction, heavy steel mats being provided over the columns instead.

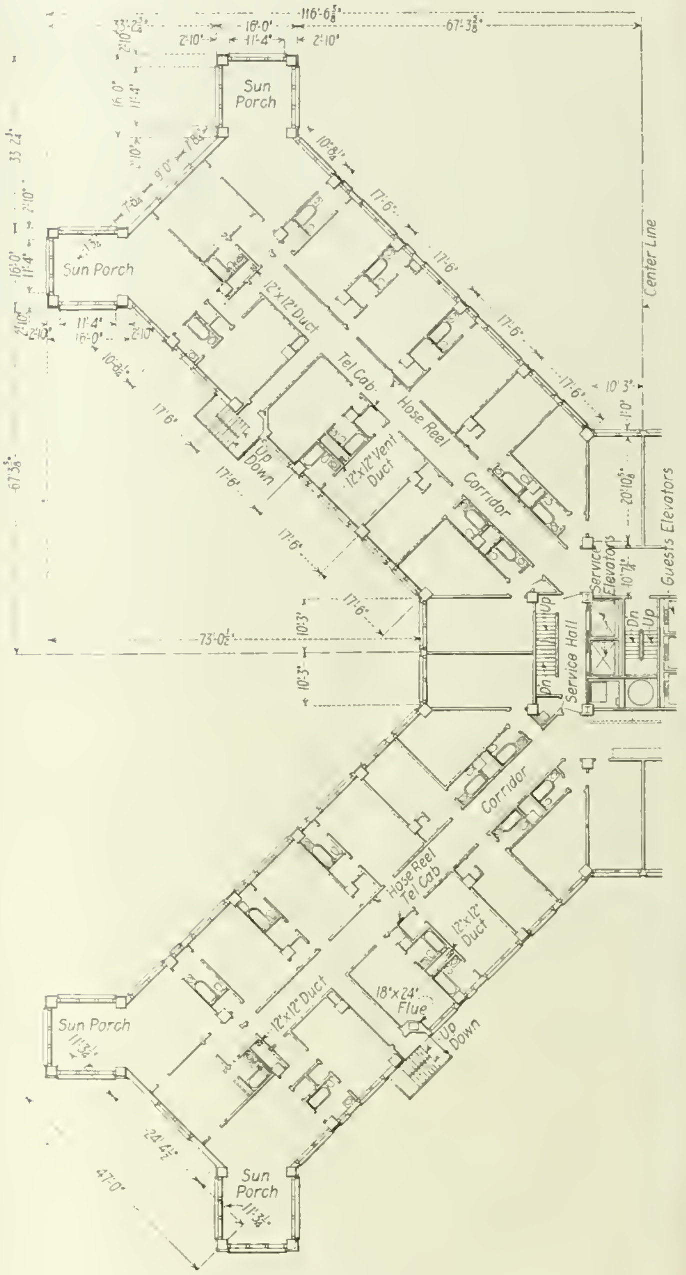


Fig. 1—Half Typical Floor Plan of Edgewater Beach Hotel Building, Chicago, Ill.

Architectural Features.—Figure 1, which is a typical floor plan, shows the general form of the building and gives the arrangement of the rooms, elevators and stairs. Figure 2 is a sectional elevation of the hotel building showing the general architectural design.

On the ground floor the front portion of the building facing Sheridan Road is devoted to shops. The central portion of the ground floor houses the elevator lobby and shafts, the depressed boiler room, and a club room. The northeast wing contains the kitchen and various storage rooms for supplies, while the southeast wing is given over to a large banquet hall and club room; between these two wings and extending to a considerable distance to the rear, there is a large storage room. The floor of the shops, elevator lobbies and club room is at elevation 8 ft. 10 in., City Datum; the billiard and locker rooms are 1 ft. lower; the kitchen floor is at elevation 6 ft. 3 in.: while the boiler room and the rear storage room floors are at elevation 2 ft. 10 in.

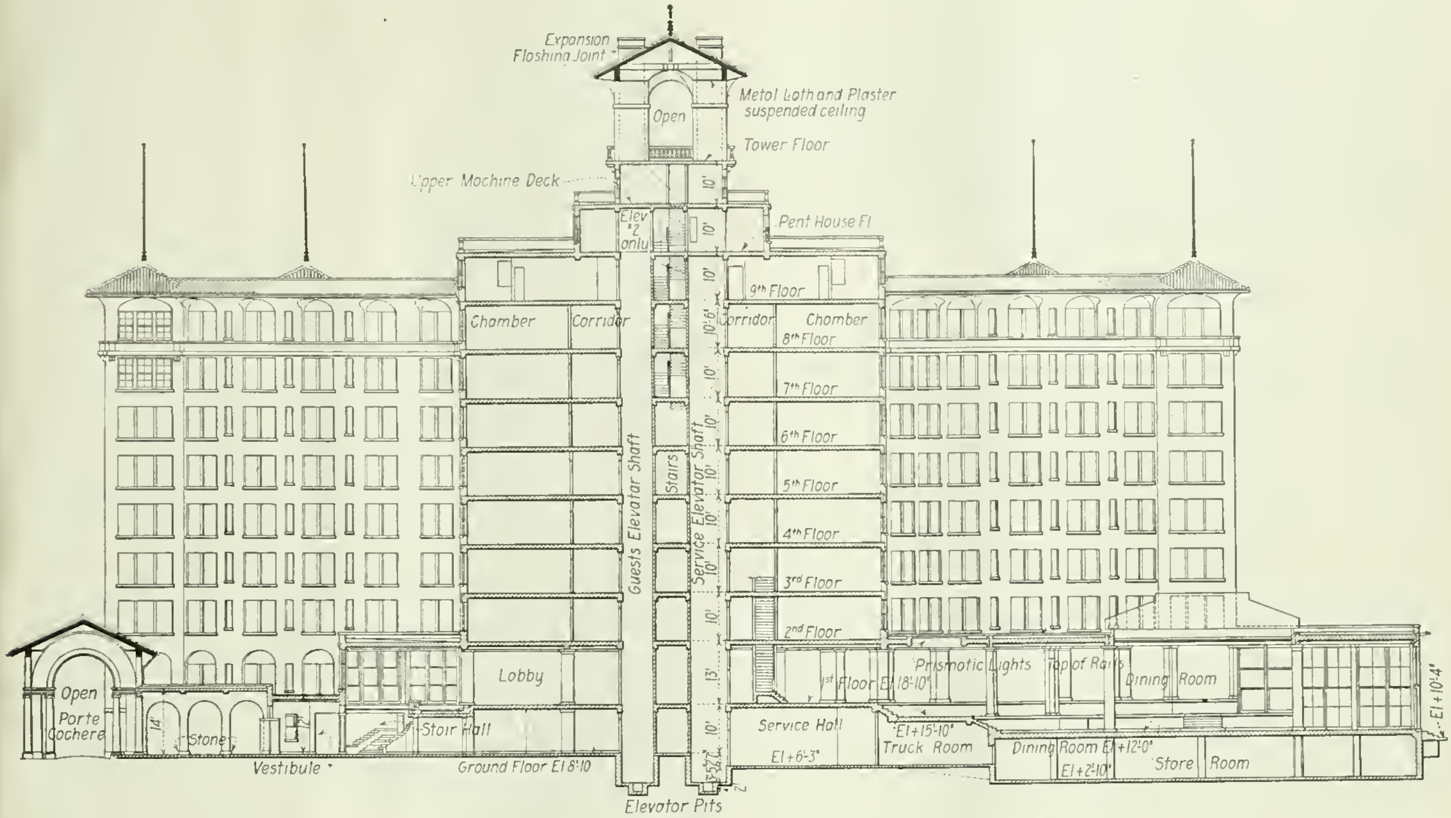


Fig. 2—Sectional Elevation of Edgewater Beach Hotel Building, Looking North.

With the exception of the dining room, which occupies the rear portion of the first floor and is at elevation 12 ft. 0 in., the first floor is at elevation 18 ft. 10 in. At this level there is a large lobby surrounding the elevators, a lounging room in the southeast wing, and display and guest rooms in the wings facing Sheridan Road.

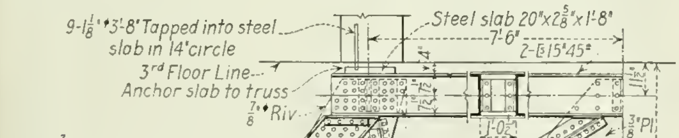
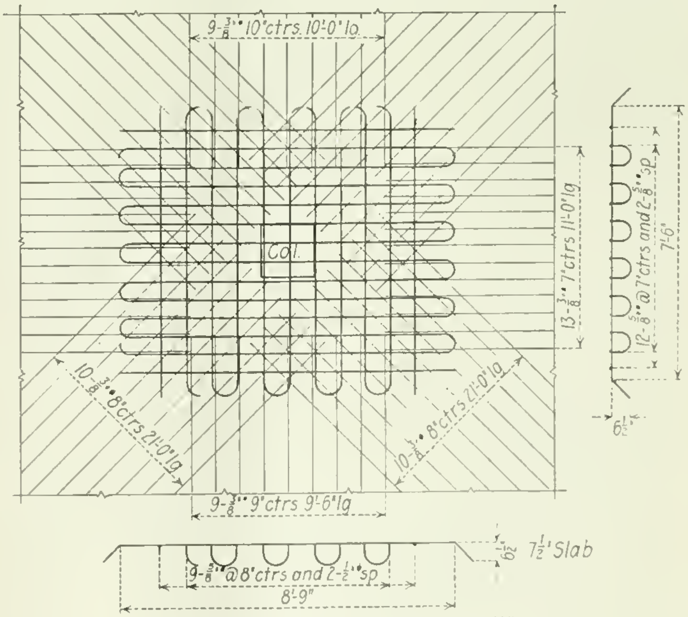


Fig. 3—Details of Steel Trusses in Second Story of Edgewater Beach Hotel Building—These Trusses Carry Two Lines of Concrete Columns.

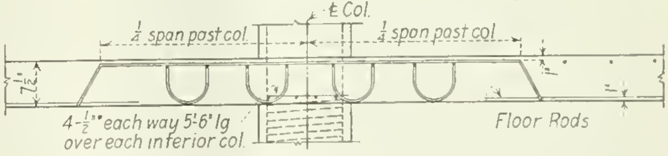
The arrangement of corridors and guest rooms on the typical floors is shown in Fig. 1. The typical story height is 10 ft.

Structural Features.—With the exception of the four steel columns which are a part of the central tower all columns are reinforced concrete. The columns have shallow reinforced concrete footings resting on clusters of wood piles, the tops of the piles being at elevation —1.0 ft. In general, the columns are square, and all are reinforced with longitudinal bars and spiral reinforcement.

To provide large unobstructed rooms on the first floor of the northeast and southeast wings, steel trusses are used in the second story to carry the two interior lines of concrete columns. These trusses have a span of 32 ft. 2 in., center to center of bearings, and a height of



(a) Mat A for Central Line of Columns in Wings



(b) Typical Arrangement of Mat over Interior Col's. in Wings

Fig. 4—Details of Typical Panel of Floor Construction Showing Arrangement of Reinforcement.

10 ft. 0 in., center to center of chords; they are supported on lines of auxiliary concrete columns placed about 6 ft. inside of the exterior column lines. Figure 3 shows details of these trusses.

To avoid the use of enlarged column heads, and thus provide flat ceilings, a heavy reinforcing mat is placed over each column, extending one-fourth of the panel length in each direction. The floor slab has a thickness of 7½ in. The Barton spider web system of flat slab floors is used. Figure 4 is a typical panel of the floor construction showing the arrangement of the reinforcement.

Personnel.—The building was designed by Marshall & Fox, architects, of Chicago, and is being constructed by the Darling & Eitel Co., also of Chicago.

THE PROPOSED FEDERAL AID ROADS LAW.

(Contributed.)

One of the most important and pressing matters with which the Congress must deal at its present session is the matter of good roads. A month ago, or more, the so-called "Shackleford Bill" passed the House by an overwhelming majority and was sent to the Senate. It carried an annual appropriation of $25,000,000 out of the General Treasury to aid the States in the construction and maintenance of rural post roads and was sent to the Senate for its consideration. There was something of a passing flurry in that body as to which committee the measure should be referred, which was amicably adjusted by reference from the committee on agriculture and forestry to the committee on post offices and post roads. That committee has completed its work and reported a bill very much like the House measure in its general terms but differing in important features from the House bill.

The Senate bill provides for the year 1917 an appropriation of $5,000,000, for the year 1918 an appropriation of $10,000,000, for the year 1919 an appropriation of $15,000,000, for the year 1920 an appropriation of $20,000,000, and for the year 1921 an appropriation of $25,000,000. The management, distribution and expenditure of the appropriations so provided are to be entrusted to the Secretary of Agriculture and under conditions, clearly stated in the measure, which he is directed to require. These conditions, briefly stated, are to prevent the waste of the funds taken out of the Federal Treasury so that each dollar expended in the work of making good roads shall have a dollar's worth of work to show for it. "The Secretary of Agriculture is authorized to co-operate with the States;" "the Secretary of Agriculture and the State Highway Department of each State shall agree upon the roads to be constructed therein and the character and method of construction." After making certain clearly stated deductions to cover the expense of administration from the fund provided by the United States, "the Secretary of Agriculture shall apportion the remainder of the appropriation for each fiscal year among the several States," one-third in the ratio which the area of each State bears to the total area of all the States; one-third in the ratio which the population of each State bears to the total population of all the States, and one-third in the ratio which the mileage of rural delivery routes and star routes in each State bears to the total mileage of rural delivery routes and star routes in all the States at the close of the next preceding fiscal year. "The Secretary of Agriculture and the State Highway Department of each State may jointly determine at what times, and in what amounts, payments, as work progresses, shall be made under this act, and payment of these amounts is to be made by the Secretary of the Treasury on warrants drawn by the Secretary of Agriculture. All road projects under this act are to be approved by the Secretary of Agriculture before they can be made a charge against the appropriations made by Congress, the act providing that he shall approve plans, specifications and estimates. The States or their subdivisions must maintain the roads built with the Federal aid, for the Secretary of Agriculture is authorized to withhold further such aid where maintenance is not properly carried on.

The Senate bill is a purely business measure. The conditions are plain and simple—ratio in area, in population, in mileage. Better than all this, however, is the provision that the building of good roads for postal purposes, which will be available for industrial and commercial purposes also, is to be a copartnership matter between the Nation and the States. The United States will match dollars with the States. Under the conditions noted in the bill, the United States will pay a dollar to the States for the building of rural post roads for every dollar they spend for the same purpose; no more and no less. The States that pay nothing on their own account will get nothing under the terms of the bill and whatever the States do in road-building under this bill must be done under the supervision and with the approval of the Secretary of Agriculture.

CONSTRUCTION PROGRESS ON THE BLOOR STREET VIADUCT, TORONTO, CANADA.*

The Bloor Street viaduct, which is under construction in Toronto, Canada, is an extension of Bloor St. East, designed to provide a direct route from a section which is already served with a car line but is somewhat isolated by the deep ravine of Don River and by the Rosedale ravine, which merges into the Don Valley. As an extension of Bloor St. eastward would cross these two ravines near their junction, and would thus make an unfavorable location for a viaduct, it was decided to deviate the course slightly by deflecting the street in one direction and then back again to Bloor St. prolonged. The improvement is being built in four sections: Section A is simply an earth fill along the south bank of the steep ravine; B is termed the Rosedale section, crossing Rosedale ravine approximately at a right angle; C is a concrete roadway across the point of land between the two ravines; and D is a viaduct across the Don Valley, this being the longest section of the improvement.

Don Valley Section.—The Don Valley section of the viaduct is 1,680 ft. long, including its approaches, and is about 125 ft. above the Don River. The bridge proper is 1,077½ ft. long and consists of five three-hinged steel arch spans between mass-concrete piers, the latter extending up to the roadway. The central span over the Don River has a length of 281 ft. 6 in., center to center of end pins. This central span is flanked by two spans of 240 ft. each, center to center of pins. The two outside arch spans are each 158 ft. long, center to center of end pins. Each span consists of four arch ribs, which rest on granite blocks embedded in the concrete. The west approach consists of an 80-ft. steel span, masked with concrete side walls and a suspended ceiling, while the east approach consists of a steel trestle, also masked with concrete side walls. The four piers in the central portion of the bridge rest on solid rock. The deepest excavation required for these piers was 47 ft., the depths of the remaining excavations varying from 30 to 40 ft. The other three piers have spread footings resting on hard, dry clay, which lies from 10 to 14 ft. below the ground surface.

Work was commenced on the Don section on Jan. 16, 1915, and was carried on continuously up to the middle of December. The substructure had been practically completed before the advent of cold weather, and construction work along this line has been stopped until after the erection of the steel superstructure, when the remainder of the concrete will be placed. All foundations in the Don section are completed, and about 60 per cent of the concrete is in place; about 27,000 cu. yd. of concrete have been poured in the various piers. About 40 per cent of the Don section is ready for the erection of the steelwork. All excavation for the caissons has been finished, and the only work which remains is the dressing of the eastern and western slopes and the grading around the foot of the piers. The excavations completed thus far comprise about 43,000 cu. yd. of earth.

In all caisson work, except at pier D, Lackawanna steel sheet piling, heavily braced, was used. Some difficulty was experienced in excavating for some of the footings, due to deep layers of quicksand; in such places special care was necessary to secure rigid and tight-fitting forms.

---

*Based on an article in The Concrete Record.

In general, pulsometer pumps were used in unwatering the caissons. In the case of two piers the unwatering operations were accomplished with great difficulty.

On the Danforth approach the embankment was cut away to permit pier A to be placed as far east as practicable, to accommodate some railroad tracks. This excavation work was done by a Marion steam shovel, the earth being placed in dump cars which were hauled up an incline over the railroad tracks and distributed from there wherever needed in the Don Valley for grading about piers and buildings. About 25,000 cu. yd. were excavated and distributed in this manner.

The distribution of all excavated material and also all concrete material is handled by a standard 1,200-ft. Lidgerwood cable running from the east end of the Don Valley to the highlands in Rosedale. This cableway, with its bucket, is operated by a two-drum hoisting engine, placed in an engine house in the Don Valley. Operations are carried on by means of electric signals, a man on the scene of operations giving his signals to the operating room by means of a switch. Materials for the west portion of the Don section are delivered on cars on railway sidings. The cement is unloaded onto narrow-gage hand trucks, and from them into storage sheds, whence it is distributed to the mixing hopper by means of the cableway, as required. Sand, gravel, and broken stone are unloaded into bins or storage piles adjoining the tracks by clam-shell buckets. From there the material is discharged by gravity through chutes into a hopper, and then elevated in scoop buckets, attached to an endless chain, to the mixing platform; or it is conveyed directly from the storage piles by means of the cableway to another mixing plant on the side of the hill at the west end of the viaduct.

A gravity method of distribution is used throughout. Concrete is raised to a point 50 ft. above the level of the grade line of the viaduct by means of five wooden towers placed along the viaduct. From the towers the concrete is chuted to place.

Relaying concrete from tower to tower was carried on with a fair measure of success. The aggregate for the east end of the Don section is delivered on sidings where it is unloaded by clam-shell buckets and delivered directly to the mixing hopper; the concrete is then distributed to the various piers.

After the forms are removed, and the concrete has hardened sufficiently, a gang of men is set to work on the exterior finish. The large projections are first knocked off and the surface made fairly smooth with steel tools and carborundum bricks. An electrically-driven carborundum disc, operated by two men, is then used to give the surface a smooth, uniform finish.

The construction plant includes a carpenter shop, a blacksmith shop, and a machine shop. During the early part of construction, storehouses and boarding rooms were erected. The main water supply is brought from the city mains on Danforth Ave. In general, the plant is steam driven. Boilers located at various points along the viaduct serve the various hoisting engines and concrete mixers. A few small motors, however, are used for driving some wood-working machinery and small tools. The construction force varies from 200 to 250 men.

One steel erection traveler has already been assembled at the west end, on the highlands at Rosedale; another will be erected on the east approach. Erection of the steelwork will be carried on simultaneously from both ends by two gangs.

Rosedale Section.—The Rosedale section of the viaduct is 600 ft. long, and is 95 ft. above the roadway in the Rosedale ravine. It consists of three main piers, with a three-hinged steel span of 190 ft. between the two piers adjoining the roadway, a steel girder span masked with concrete, and steel trestle work in the approaches, also masked with concrete. All piers are of concrete and extend up to the roadway.

The two piers of the arch span are carried below the surface of the rock 3 or 4 ft. to a solid foundation. The rock lies at a depth of about 36 ft. below the roadway in the ravine. The other piers have spread foundations resting on hard, dry clay.

Similar concreting methods are used in this section to those employed in the Don section. Two wooden towers, one on each bank, are used to elevate the concrete into steel distributing hoppers, from which it is chuted to the various piers and abutments. The materials for the Rosedale section had to be hauled, which rendered this part of the work more difficult than in the Don section, where all materials were distributed either by cable or by dump cars.

Personnel.—The general contractor for the Don section is the Quinlan & Robertson Co., Ltd., and the sub-contractor for the steel superstructure the Hamilton Bridge Works, Ltd. For the Rosedale section the general contractor is the Dominion Bridge Co., Ltd., and the sub-contractor for the concrete work the Raymond Construction Co.

THE NATIONAL SEPTIC PROCESS PROTECTIVE LEAGUE ORGANIZES.

The National Septic Process Protective League was formed at a meeting of the League of Iowa Municipalities, held in Des Moines, Iowa, on March 14, 1916. Dr. H. M. Bracken of Minneapolis, Secretary of the Minnesota State Board of Health, was elected President, and F. G. Pierce of Marshalltown, Iowa, Secretary-Treasurer. The object of the league is to defend all suits filed against its members for the infringement of Cameron Septic Tank patents. All municipalities, corporations, companies and individuals interested in sewage disposal are eligible to membership, subject to the approval of the executive committee, upon the payment of the proper fee.

Quite recently a number of Iowa municipalities have been notified by the Cameron Septic Tank Co. of patent infringement for the use of septic tanks, filters, and other appurtenances of sewage disposal plants. To consider the claims of the Cameron company for royalties on sewage disposal plants, a meeting of the League of Iowa Municipalities was held in Des Moines on March 14, 1916. Dr. J. F. Cole, president of the league, presided.

Prof. A. Marston of Ames, Iowa, discussed the development of septic tanks and the litigation in regard to the claim of the Cameron company for royalties. H. E. Sampson, Assistant Attorney General of Iowa, explained the legal status of the Cameron claims, especially in the light of the recent decision against the city of Winchester, Ky. Following a general discussion a committee was appointed to report upon a plan of organization. The committee brought in the following resolution, which was adopted:

> Whereas, The Cameron Septic Tank Co., of Chicago, is making demands upon municipalities throughout the United States for the payment of excessive royalties, on account of a certain alleged patent which it claims to own; and
>
> Whereas, This conference has been advised by able attorneys that in their judgment the alleged patent of the Cameron Septic Tank Co. has already expired, and that it is no longer a live and valid patent upon which royalties can legally be collected; and
>
> Whereas, It is the judgment of those from the several states represented in this conference that the interests of the taxpayers and general public can best be protected by contesting the validity of said alleged patent, by ascertaining the scope of its valid claims, if any there be, and by refusing to pay any and all royalties to the said Cameron Septic Tank Co. on account of said patent, until after the courts of final jurisdiction have upheld the validity of such patent and the liability for such royalties; and
>
> Whereas, The expense of defending suits of this character would prove burdensome to a single municipality; and
>
> Whereas, The benefits which would accrue from such a suit, if successfully contested, would prove of value to all of the municipalities from which royalties are being demanded, and particularly to the taxpayers of such municipalities; now, therefore, be it
>
> Resolved, That the National Septic Process Protective League be and the same is hereby formed for the purpose of aiding in the defence of any suit brought by the Cameron Septic Tank Co. against any municipality, company, corporation, state institution, or private individual which is a member of this league, when such suit involves the validity of said patent.

The committee presented the following report, which was adopted:

It was agreed to recommend that a league be formed, to be known as "The National Septic Process Protective League," with officers as follows: President, Vice President, and Secretary-Treasurer; to have also a Board of Directors, made up of two representatives from each state, and an Executive Committee, consisting of the officers of the league and four of the Board of Directors, chosen by the Board of Directors.

It was further agreed to recommend that the membership be unlimited, open to municipalities, companies, corporations, state institutions and private individuals interested in sewage disposal. All members to be subject to the approval of the Executive Committee.

It was agreed to recommend that assessments for raising funds to carry on this work be based on the population of the municipalities, graduated as follows:

Less than 2,000 population	$10
2,000 to 5,000 population	15
5,000 to 10,000 population	20
10,000 to 20,000 population	25
20,000 to 50,000 population	30
Over 50,000 population	35

Subsequent to the adoption of the above report, a permanent organization was effected, with the following officers: H. M. Bracken, President; Elliott Kimberly, Vice President; F. G. Pierce, Secretary-Treasurer. Following are the members of the Executive Committee: C. A. Haskins of Kansas, Paul Hansen of Illinois, Lafayette Higgins of Iowa, A. Marston of Iowa (advisory member), and the officers of the league, ex-officio members.

The following Board of Directors from several states was duly elected. The Secretary, on the advice of the President, was instructed to complete the list of directors for the different states:

Board of Directors.

For Iowa—Dr. J. F. Cole, President League of Iowa Municipalities; Lafayette Higgins, Engineer State Board of Health.

Kansas—C. A. Haskins, Engineer State Board of Health. (One other director to be chosen.)

Ohio—W. H. Dittoe, Engineer State Board of Health. (One other director to be chosen.)

Illinois—Langdon Pearse of Chicago; Paul Hansen, Engineer State Board of Health.

California—W. J. Locke, Secretary League of California Municipalities; Chas. G. Hyde, Consulting Engineer State Board of Health.

Minnesota—H. A. Whittaker, Minnesota State Board of Health; G. A. Gsell, Secretary Minnesota League of Municipalities.

The meeting was attended by about 35 delegates, representing the states of Iowa, Kansas, Minnesota and Ohio. It was further recommended that two delegates should be chosen from states not represented, upon the approval of the President and the Secretary, as members of the Board of Directors.

The Secretary was directed to correspond with a competent patent attorney to serve as attorney for the league.

It is interesting to note, as brought out in the discussion, that the alleged infringements of the Cameron Septic Tank patents are not confined to what are frankly called "septic tanks," but extend "to those which employ putrefactive reduction of sewage solids, but which for purposes of evasion have been styled 'sedimentation' or 'settling tanks,' as well as to the more recently exploited 'Imhoff' or 'two-story' septic tank."

It is further important to note that the terms for licenses are based on the cost of the plant, upon the length of time it has been in operation, and are 3 per cent per annum on the original cost of the complete plant and subsequent additions. "Including the tanks, contact beds, filters or other appurtenances for the number of years each plant has been in operation to date of settlement, plus an additional 3 per cent for the remaining unexpired term of the patent."

The quoted sentences in the last two paragraphs are from letters written by an officer of the Cameron Septic Tank Co.

CONDITION AND CARRYING CAPACITY OF OLD CAST IRON WATER PIPE AT HARTFORD, CONN.*

By Caleb Mills Saville, Chief Engineer, Board of Water Commissioners, Hartford, Conn.

Ground was broken for the Hartford water works in 1854 and some of the pipes laid in that year are still in service, as shown in Table I.

Wrought-iron, cement-coated mains came into vogue in 1863 on account of the comparatively low cost and for

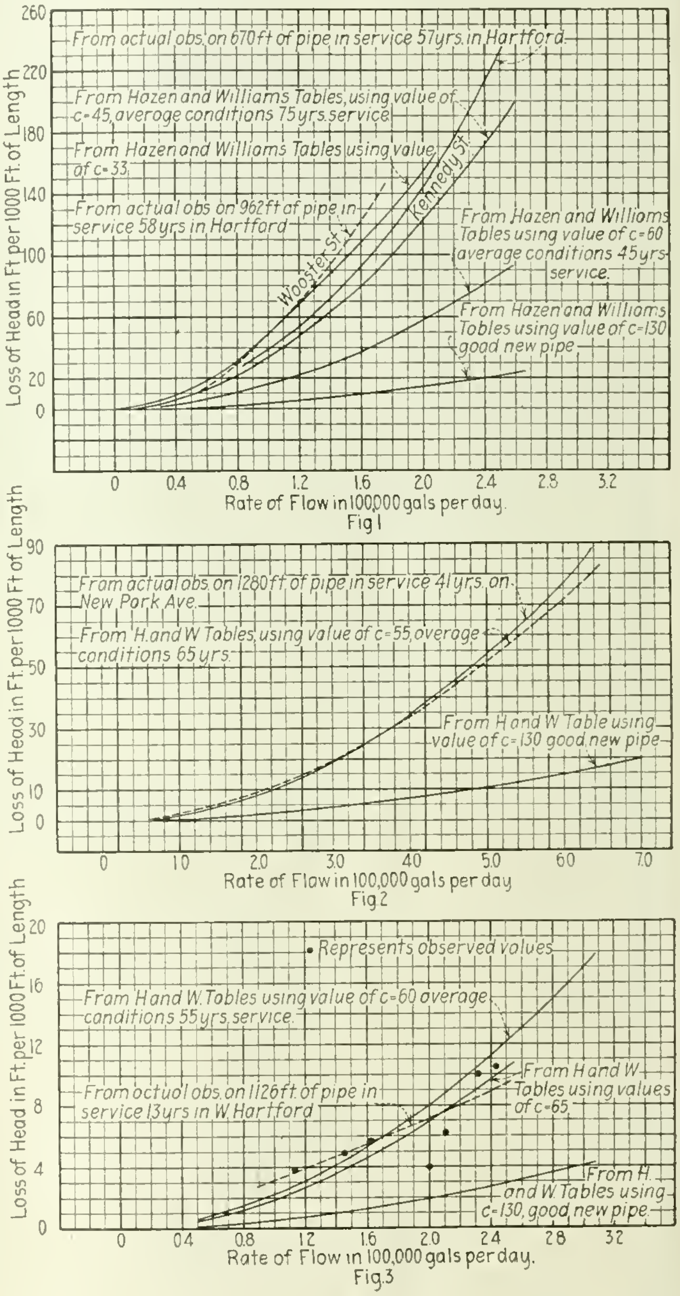


DIAGRAM SHOWING LOSS OF HEAD IN OLD 4 AND 6-IN. CAST IRON WATER MAINS, HARTFORD, CONN.

Fig. 1—Loss in 4-in. Mains in Use Over 50 Years on Wooster and Kennedy Sts., Hartford. Fig. 2—Loss in 6-in. Main in Use 41 Years in New Park Ave., West Hartford. Fig. 3—Loss in 6-in. Main in Use About 13 Years in New Park Ave., West Hartford, Conn.

TABLE I.
OLD CAST IRON PIPES IN SERVICE IN 1915, HARTFORD WATER WORKS.

Year laid.	Length in feet. 3-in.	4-in.	6-in.	8-in.	10-in.	12-in.	16-in.	Total.
1854	......	......	1,921	2,326	......	1,060	......	5,307
1855	......	......	3,071	1,945	2,525	2,361	6,864	16,766
1856	442	193	13,852	4,113	1,072	......	......	19,672
1857	......	1,220	13,479	6,238	457	......	......	21,394
1858	......	811	780	......	......	......	......	1,591
1859	......	3,351	4,882	......	......	......	......	8,233
1860	......	......	2,177	......	......	......	......	2,177
1861	......	......	3,438	......	......	......	......	3,438
	442	5,575	43,600	14,622	4,054	3,421	6,864	78,578

---

*From paper before the New England Water Works Association.

a number of years no cast-iron pipe was laid in Hartford. Owing to its greater reliability, cast-iron gradually replaced the cement-lined pipe and only a comparatively little of this latter pipe is now in use in the city. It is interesting to note that probably the most of the old cast iron pipe is uncoated and was cast in a horizontal position instead of vertically as at present.

During the past year new pipe has been laid in many streets formerly served by pipes laid many years ago. This action has been taken, not because intrinsically the pipe had worn out or become useless, but solely because the community served is now a populous city district rather than a sparsely settled suburb. If our present judgment in distribution layout can provide as adequately for 55 to 60 years' service in the future surely we need not be much disturbed. The iron in this old pipe was of excellent quality, and, except for the cost of salvage, this pipe might well have been used elsewhere. The cost of removing these pipes, however, is usually found to exceed their value on account of other underground structures, street railway tracks and improved street surfacing, to say nothing of the often very erratic alignment of the old layout. Some of it was badly tuberculated and other was partly filled with sediment, but if the pipe had not been too small for modern requirements in this district it probably would have paid to clean it. So far as permanency goes, all of this pipe shows that cast iron is an ideal material for water pipes, and that up to the present time no other substance has been found from which generally such satisfactory results can be obtained. There are three principal features that should be considered in selecting water pipes, permanency, carrying capacity, and cost. Fifty-five to 60 years' service and a condition such that life ahead cannot be estimated certainly meets the first requirement. Well-laid, clean or cleaned cast iron pipes have a carrying capacity not greatly inferior to that of any other materials that have been used, and if capitalized cost based on length of service is taken as a criterion it appears that all these requirements for water pipes have been met.

So far as possible, when these old pipes are replaced, an endeavor is made to get some idea of their condition and capacity. The condition is obtained from an inspection of sections cut from the main. The capacity is found by discharge tests. In these tests the quantity is obtained either by using a meter or by pitometer, pressure gages placed near the inlet and outlet ends of the pipe giving fair information regarding friction losses under varying conditions of flow.

Meters of standard makes are used on the tests and these are tested before and after. The gages are 6-in. Crosby Standard Test Gages, graduated in pounds per square inch from 0 to 120, with corresponding heights of water in feet from 0 to 277. These gages are tested on an oil-testing machine before and after using, in the position as used on the pipe test, and proper corrections made for error in registration due to this cause. Below are given summaries of the tests of several pipe lines which had been in actual use for a considerable period:

Street.	Size, in.	Length, ft.	Age, yrs.	Figure No.
Kennedy St.	4	670	57	1
Wooster St.	4	962	56	1
New Park Ave...............	6	1,280	41	2
New Park Ave...............	6	1,126	13	3

The results of these tests are plotted in Figs. 1-3 herewith.

No discussion will be attempted at this time of the problems suggested by these tests, as it is hoped at a later date to have more information regarding the depreciation in carrying capacity of cast iron pipe after period of service under Hartford conditions. In general it will be noted that the curve derived from experiments follows closely the shape of those plotted from the Hazen-Williams formula, although they do not agree as to age. This difference is probably due to character of incrustation and other impediments of local significance. It is perhaps of interest also to note that the 4-in. pipe about 57 or 58 years old has a carrying capacity equivalent to a smooth new pipe 2½ in. in diameter. Such condition must necessarily have a bearing on the matter of estimating present values of pipe lines which have been laid for a number of years. The worth of a distribution system consisting of cast iron mains should be based on consideration of adequate size, interior condition and salvage value of the pipes, with little or no account being made of actual depreciation of the pipes except by electrolysis or other special conditions.

CHECKING EXCESSIVE WATER CONSUMPTION IN FRAMINGHAM, MASS.

The water department of the town of Framingham, Mass., sends out a printed circular to metered water consumers when the registered consumption for the preceding quarter was abnormally high. The cost of the water used by the consumer is written in on the circular opposite the five causes of water waste enumerated. The text of the circular follows:

The readings of your water meter show that a larger amount of water has passed through your meter during the past three months than is ordinarily used. If you are unable to account for this extra amount we would suggest the following as common causes of waste of water:

1. Defective pipes.
2. Defective ball cocks or valves in water closet and boiler tank.
3. Leaky faucets and stop cocks.
4. Careless use of hose.
5. Allowing water to run in winter to prevent freezing and in summer for cooling.

Experiments have shown that under our pressure and at our rate (25 ct. per 100 cu. ft.) a hole 1/32 in. in diameter, which is so small that an ordinary pin will completely fill it, in three months will waste, if running constantly, a quantity of water that amounts to $11.65.

By far the greatest number of leaks occur in water closet tanks through imperfect seating of the ball cocks. A stream of water 1/16 in. in size may easily escape through a slightly defective ball cock causing a waste of water, amounting in value to $26.93 in three months.

Unpleasant surprises in water charges may be wholly prevented if owners will read their meters frequently and with especial care in extreme weather either in summer or winter.

Should a meter indicate a sudden increase in consumption with no apparent cause, one of two things has happened: a leak has started or water has been allowed to run to waste.

To Discover Leaks.

If a hissing or roaring noise is heard in the water pipes, it is evidence of a leak, and by listening with the ear pressed closely against the pipe or faucet, a very small leak may be located by its sound. Close the house stop cock in the cellar, and if the sound still continues notify the Water Department, as the trouble is probably outside the house. If, however, the noise stops, the leak is inside, and the aid of a plumber should be called. The existence of a leak inside of the house may be proven by reading the meter at night after all use of water has ceased, and again in the morning before any use begins. The difference between these readings is the measure of the leakage.

Accuracy of Water Meters.

It is impossible for a water meter to operate unless the water passes through it. The flow of the water causes the piston to move and the meter to register. A water meter may become obstructed so that it fails to register all the water which passes through it. This, however, is in favor of the consumer. Meters are rated and tested in the factory and again tested at the department shop before being installed.

The Water Department does not assume the oversight of the water pipes and fixtures within metered premises, nor any responsibility for the use or waste of water therein, but sends this notice as a courtesy, as all water that passes through a meter will be charged for, whether used or wasted.

Yours respectfully,
TOWN OF FRAMINGHAM WATER DEPARTMENT.

AUTOMOBILE TRANSPORTATION FOR COUNTY ENGINEERS.*

By W. D. Maxwell, County Engineer, Sac County, Iowa.

It is frequently remarked, especially by opponents of the good roads movement, that the automobile is responsible for the demand for roads, and consequently is responsible for the creation of the job of county engineer. A converse statement is equally true, that is, the job of county engineer at once creates a demand for an automobile.

The average county engineer travels over the roads about 10,000 miles per year, which is roughly equivalent to completely traversing the entire mileage of road in the county about ten times. It is manifestly impossible with any means of transportation other than the automobile, for the engineer to cover this distance and have any time left for work.

In most cases the Ford is the car selected for the coun-

---

*Paper read at the annual meeting of the Iowa Engineering Society.

TABLE I.—DATA ON PERFORMANCE OF FORDS IN SERVICE OF COUNTY ENGINEER.

		Gasoline		Oil				Tires			
Year	Miles.	Gal.	Cost.	gal.	Cost.	Labor.	New parts.	Repair.	New.	Miscellaneous.	Total.
Car No. 1—Ford Touring Car.											
1913	6,520	365	$ 73.00	22	$13.20	$ 16.40	$ 11.85	$17.20	$ 40.20	$19.10	$190.95
1914	10,107	598	96.80	59	35.32	111.45	91.76	17.60	57.45	14.10	424.48
1915	3,568	294	42.26	25¼	15.05	49.70	49.00	9.25	21.30	19.35	205.91
Totals	20,195	1,257	$212.06	106¼	$63.57	$177.55	$152.61	$44.05	$118.95	$52.55	$821.34
Average cost of gasoline, 16.78 ct. per gal. Average travel per gal., 16.07 miles. Total maintenance, $821.34 = 4.05 ct. per mile.											
Car No. 2—Ford Touring Car.											
1915	6,071	390	$51.60	19½	$11.55	$5.45	$0.10	$4.80	$27.00	$5.45	$106.04
Average cost of gasoline, 13.25 ct. per gal. Average travel per gal., 15.58 miles. Total maintenance, $106.04 = 1.75 ct. per mile.											

ty engineer's use, the selection being prompted by low first cost, low cost of maintenance, and the well known ability of the Ford to get back to the starting point on time. In some instances where large parties of men with considerable equipment are to be transported, a larger and more powerful car than the Ford is more convenient, but from the standpoint of economy a large car should not be considered.

A small amount of additional equipment should be added to the Ford as it comes from the factory, but there is no necessity for loading he car down with superfluous accessories. The extra radius rod trusses are a good investment from the standpoint of safety. All four wheels should be fitted with 3½-in. tires because of the great convenience of having all tires alike, and because the large tires in front wear longer. Some arrangement of straps or hooks alongside the body of the car is advisable for carrying long rods and other surveying apparatus. An electric starter is convenient but is not essential.

In the opinion of the writer, it is not economical for the county engineer to drive one car more than two seasons. At the end of that time the car should not be worn out by any means if it has been properly taken care of, and should have a good second-hand value. However, it will have reached the point where considerable tinkering and more or less repairing is necessary, so that maintenance is much higher, and worse yet, the engineer loses valuable time. Consequently a comparatively new car is the cheapest. Under some conditions, a new car each year may be most economical, but ordinarily a Ford will do fairly well for two running seasons.

The accompanying cost data, Table I, which has been carefully compiled, gives a record of the performance of the same car during several seasons, and also affords a comparison between an old car and a new one. The figures are not intended to represent any unusual record, but simply to show how transportation has been obtained, under ordinary conditions for one county engineer.

Total Costs, Including Car.

Car. No. 1.

Car cost, complete	$ 660.00
Car sold for	200.00
Net cost	$ 460.00
Maintenance	821.34
Total	$1,281.34

Which is 6.34 ct. per mile for 20,195 miles.

METHOD AND COST OF REMODELING THE LAKE FOREST, ILL., SEPTIC TANK INTO A MODERN TWO-STORY SETTLING TANK.*

By N. N. Campbell, Civil Engineer and Surveyor, Lake Forest, Ill.

Lake Forest, Ill., like many other towns and cities which have sewage disposal plants of one type or another, found that with the increase in population, the extension of its sewer system, and the correspondingly greater amount of storm water that found its way into the sanitary sewers, its sewage treatment plant was no longer of sufficient capacity properly to do its work and, as a result, the outgrown plant caused a nuisance in the community.

The Original Plant.—The sewer system and the sewage disposal plant of Lake Forest were designed by Alvord & Shields and construction began in 1902. The disposal plant consisted of a grit chamber 4 ft. by 16 ft. by 7 ft. deep into which the two main outlet sewers emptied. From this grit chamber the sewage entered a septic tank through six submerged openings controlled by 6-in. shear valves.

The septic tank was 60 ft. long, 18 ft. wide, and ranged from 6 to 8 ft. in depth, and had a total capacity of 50,000 gal. It consisted of two chambers, the first was divided into two equal compartments by a 16-in. brick wall, and the second was divided, by two 12-in. brick walls, into three unequal compartments 4 ft., 5 ft. and 7 ft. in width, respectively. The two chambers were divided by a double 9-in. brick wall or trough, the openings in these walls being staggered so as to break up any direct flow of the sewage through the tank.

The effluent from the septic tank was drawn off over weir gates into a dosing chamber having a capacity of 8,140 gal. The dosing chamber was equipped with ten 12-in. siphons and an automatic device for alternating the discharge from one siphon to another, and discharged the effluent onto a filter bed.

The filter bed was divided into ten equal units separated by light wooden partitions and having an area of approximately 3,200 sq. ft. each so that the entire area of the filter bed was approximately three-quarters of an acre. The beds, with the exception of one which was filled with cinders, were made of ordinary beach sand and gravel and were underdrained.

The distribution of the effluent from the septic tank onto the filter beds was accomplished by means of wooden troughs extending over the center of the beds and provided with small side openings. The underdrains of the filter beds discharged at the shore of Lake Michigan.

The plant was provided with three by-passes. Through the first of these the sewage could be turned directly into the lake without any treatment. The second by-pass was placed at the east end of the grit chamber so that excessive flow during storm periods could pass directly into the lake without treatment. The third by-pass was located at the outlet end of the settling compartments and through it settled sewage could be turned into the lake without filtration.

The Lake Forest plant was constructed in 1902 at a cost of $8,575.33 and has been in operation for 13 years. For a number of years the plant was found to be very satisfactory and efficient, but, through lack of proper care and the fact that the tank and filters were being surcharged, on account of the extension of the sewer system, the increase in population, and the greater amount of storm water that found its way into the sanitary sewers, the plant gradually got into such poor condition that at times offensive odors caused a nuisance in that vicinity.

During the 13 years the plant was in operation it had only been cleaned twice, once in 1907 and again in 1909. The average annual cost of operation and repair during this period was $534.79.

The physical condition of the plant gradually grew worse. The troughs and partitions in the filter beds had rotted and broken considerably, the tank walls about the surface of the ground were in need of repairs and a few slight leaks were noticed. The piping in the dosing chamber and the automatic operating device were badly rusted and likely to give way at any time. On the whole it became evident that something must be done at once to put the plant in such repair that it would take care of the sewage for at least a few years or until the proposed sanitary improvements along the North Shore were more fully developed.

In the spring of 1913 the mayor and city council of Lake Forest instructed Mr. Samuel A. Greeley, Consulting Engineer, to investigate the conditions at the sewage disposal plant and report to the council with recommendations for the improvement of the plant.

---

*Paper before the Illinois Society of Engineers.

On May 14 and 15, 1913, the flow of sewage to the plant was measured and it was found that out of a total of 681,000 gal. of sewage reaching the plant during 24 hours 204,000 gal. were by-passed directly into the lake without any treatment at all, that 477,000 gal. passed through the tank and only 163,000 gal. passed through the filters. In other words 30 per cent of the daily dry weather flow was by-passed directly into the lake, and 70 per cent was treated in the tank, and only 24 per cent of the daily dry weather flow was treated in the tank and filters.

On this same date a complete chemical test of the operation of the plant was made for a period of 24 hours. During the eight hours from 9 a. m. to 5 p. m. May 14th the analysis as made by Dr. Arthur Lederer is as shown in Table I.

The significant feature of this analysis is that the effluent from the tank is considerably worse from a chemical standpoint than the influent, and the effluent from the filter beds is little improved. This would indicate that fermentation in the tank was very active and that there was a rapid movement of solids from the bottom to the top of the tank and vice versa caused by the gas bubbles attaching themselves to the solids in the tank and causing them to rise, then after the gas had been liberated the solids again sank to the bottom or were carried out of the tank.

The Remodeled Tank.—Upon the recommendation of Mr. Greeley, and after several plans had been investigated, it was decided, on account of the limited funds available for this purpose, to convert the old septic tank into a modern two-story settling tank, and to enlarge it by converting the dosing chamber into a settling compartment. The filter bed being in such a clogged and bad condition that it would have to be overhauled and probably rebuilt, and as it was scarcely one-quarter large enough to care for the total amount of sewage reaching the tank at the present time, it was decided to abandon it entirely and convert a part of it into a drying bed for the sludge.

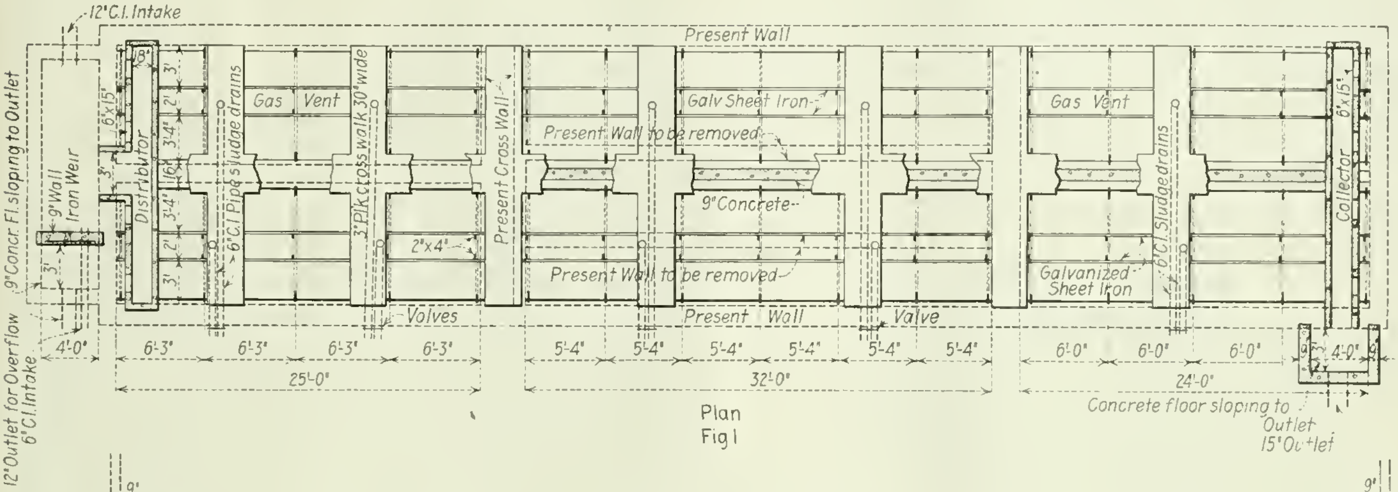
The plans for the remodeled tank were prepared in the office of James Anderson, Jr., City Engineer of Lake Forest, Ill., by the writer and are here shown in Figures 1-2-3. Figure 1 is a general plan of the remodeled tank. Fig. 3 is a transverse section of the tank, and Fig. 2 is a longitudinal section.

The work of remodeling the tank consisted of removing the old floor of the tank, underpining the old walls, and excavating to an additional depth of from 3 ft. 6 in. at the inlet end of the tank to 8 ft. 6 in. in the dosing chamber. A new reinforced concrete floor 9 in. thick making an angle 30° with the horizontal and sloping from each side toward the center of each chamber, was put in to replace the old floor. The earth under the old tank floor and walls was a good firm quality of clay and no difficulty was experienced in removing the old floor and replacing it with the new. The floor was made heavy and reinforced so as to give good and sufficient support to the walls of the tank. Figure 3 shows the general arrangement thoroughly.

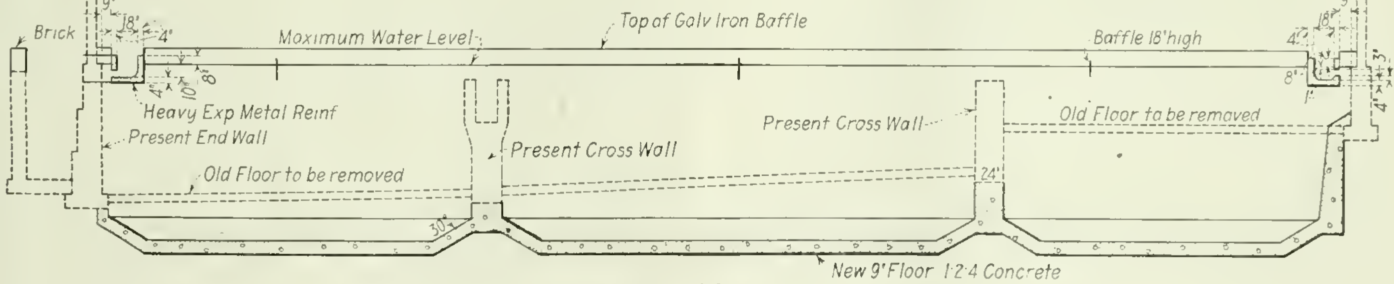
The water level in the tank was raised 1 ft., giving a total increase in the depth of the tank of from 4 ft. 6 in. at the inlet end to 9 ft. 6 in. in the dosing chamber, the total depth of the remodeled tank being 12 ft. 6 in.

The remodeled tank consists of three units, each of which is divided, by a 9-in. concrete wall, into two equal chambers. Each chamber is divided into three compartments by means of false bottom constructed of 20-gage galvanized iron on a framework of No. 1 2x4-in. pine strips heavily creosoted and making a slope of 60° to the horizontal. The two upper compartments are settling compartments and the lower and larger one is a sludge digestion compartment. Figure 3 shows the arrangement.

The three units are in reality a series of three settling tanks. The liquid is drawn off from the top of each unit



Plan
Fig 1



Longitudinal Section
Fig 2

Figs. 1 and 2—Plan of Longitudinal Section Showing How Old Septic Tank at Lake Forest, Ill., Was Remodeled Into a Modern Two-Story Settling Tank.

TABLE I.—PERFORMANCE OF OLD, OUTGROWN AND NEGLECTED SEPTIC TANK AT LAKE FOREST, ILL.

(Results given in parts per million.)

Physical appearance of sewage—Character of weak domestic sewage.

	Tank influent.	Tank effluent.	Filter effluent.
Total susp. matter	58	132	68
Volatile susp. matter	34	56	28
Fixed susp. matter	24	76	40
Oxygen consumed	33	35	18
Organic nitrogen, as-N	4.5	10.5	3.8
Free ammonia, as-N	9.6	12.8	9.3
Nitrites, as-N	0.12	0.09	0.08
Nitrates, as-N	0.51	0.53	6.2
Chlorine	36	35	33
Alkalinity (CaCo$_3$)	280	300	280

as it passes on to the next over a brick wall or partition separating the units and rising to within 12 in. of the surface, and finally is drawn off at a point 14 in. below the surface and discharged at the shore of Lake Michigan.

Ten 6-in. cast iron pipe drains were provided to draw off the sludge from the tank. Four sludge drains were placed in each of the first two units where most of the sludge is expected, and two in the third unit. The outlet end of these drains is 5 ft. 6 in. below the water level in the tank and discharge into sludge drying beds 20-ft. from the tank. Figures 1 and 3 show the arrangement.

Three baffles or scum boards 18 in. high and extending down into the liquid 12 in. and 6 in. above were placed across the tank at intervals so as to break up any surface currents that might develop.

The method devised to distribute the sewage to the several compartments is unique and very efficient in breaking up currents or vortex motion in the settling compartments. The sewage enters the tank from the remodeled grit chamber through a 3-ft. opening or trough in the center of the end wall, which leads into a reinforced concrete distributor running parallel with the end wall and placed so as to leave a 9-in. space between the distributer and the wall. The distributer is rectangular in shape and is 18 in. high and 18 in. wide internal measurements. There are four rectangular openings in this channel 6 in. by 15 in. which discharge the sewage into each of the four settling compartments against the end wall of the tank in the opposite direction to which it must flow through the settling compartments.

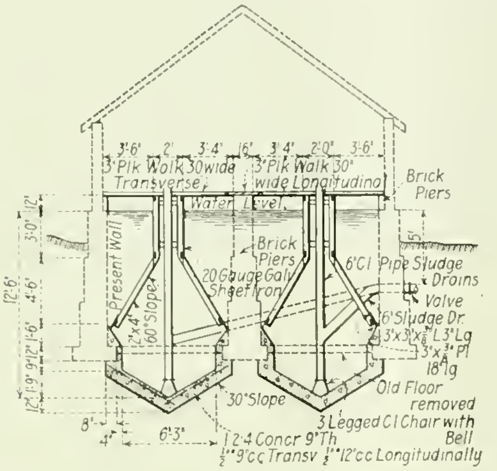


Fig. 3—Transverse Section of Remodeled Sewage Tank at Lake Forest, Ill.

The collector is a rectangular trough or channel similar to the distributor and is placed 9 in. from the outlet end of the tank with the openings in the side next the end wall. The collector also serves as a scum board or trap and prevents any light floating sludge from being drawn off with the effluent.

One longitudinal and seven transverse 3-in. plank walks 30 in. wide were built to give ready access to all parts of the tank.

The sludge drying bed is 90 ft. long and 20 ft. wide and is parallel with the tank and 20 ft. from it. The bed is divided into three sections by concrete partitions. Each section receives the sludge from one of the three units of the settling tank and is underdrained with four lines of 6-in. drain tile leading into an 8-in. carrier which discharges into the pipe leading from the settling tank. The underdrains of the sludge drying beds are covered to a depth of 12 in. with common lake shore sand and gravel.

Cost.—The cost of remodeling the Lake Forest plant and enlarging it so as to provide for the increased amount of sewage is as follows:

477	cu. ft. brick masonry at 45 ct. per ft.	$ 214.65
	Alterations on inside of tank, complete	2,800.00
222	sq. yd. plastering at $1 per yd.	222.00
190	lin. ft. 6-in. No. 2 sewer at 20 ct. per lin. ft.	38.00
220	lin. ft. 6-in. farm tile at 12 ct. per ft.	26.40
102	lin. ft. 8-in. No. 2 sewer at 45 ct. per lin. ft.	45.90
187	lin. ft. 15-in. sewer at $1 per lin. ft.	187.00
2	manholes at $25 each	50.00
220	cu. yd. excavation at 90 ct. per cu. yd.	198.00
269	lin. ft. concrete wall (sludge beds) at 36 ct. per ft.	96.84
367	lin. ft. fencing at 18 ct. per lin. ft.	66.06
	Plastering outside wall	10.00
	Setting extra valve and plug for same	4.00
	White-washing inside of building	5.75
	Removing 12-in. tile	5.50
	Pointing wall over doors, etc.	3.50
	Extra work in grit chamber (raising floor, division wall and changing iron pipe outlet of north sewer system)	56.07
	Changing wall to lower water level	6.00
	Extra for labor for examination of walls, etc.	18.84
	Total cost	$4,054.51

Design and Operation Essentials.—The approximate value of the principal elements in the remodeled tank are as follows:

1. Shape of settling compartment, rectangle over triangle.
2. Inside dimensions—Length, 86 ft.; width, 18 ft.; depth, 12 ft. 6 in.
3. Average dry weather flow per 24 hours, 681,000 gal., or 1.22 C. F. S.
4. Settling capacity, 5,670 cu. ft.
5. Sludge space, 4,000 cu. ft.
6. Ratio of floating sludge area to area of settling compartment, 30 per cent.
7. Settling period, 1.4 hours.
8. Height of sludge baffles, 12 in.
9. Lap of slots, 6 in.
10. Velocity in feet per minute through tank, 1.0.

The work of remodeling the old septic tank was completed about Dec. 1, 1915, and the remodeled tank was put in operation on Dec. 6. The sewage was turned into the tank at 9:50 a. m. and at 1:10 p. m. the tank was filled, a period of 3 hours 20 minutes. This period of filling is a little low, as the tank had been filled about two weeks previous to Dec. 6, but had to be emptied to repair a few leaks that were discovered. In making the repairs it was not necessary to remove all the sewage, so a small quantity was in the tank when the flow was turned in at 9:50 a. m., December 6th. Monday, being laundry day with the majority of families, the quantity of sewage reaching the plant during the period of filling is also larger than the normal flow. A leakage test was made and the level of the sewage in the tank was lowered only ⅜ in. in one hour's time. The effluent is apparently of a good quality and most of the solids have been settled out.

On Jan. 21, 1916, Mr. James Anderson, Jr., City Engineer of Lake Forest, and the writer inspected the tank. We found a small quantity of floating sludge in the settling compartments. This, however, did not extend beyond the first cross wall. There was quite a heavy scum of floating sludge in the gas vents near the inlet end of the tank. This floating sludge gradually diminished in amount until in the unit nearest the outlet end of the tank there was scarcely any. One of the sludge drains leading from a unit nearest the inlet end of the tank was opened, and about ten barrels of heavy sludge was drawn off before the sewage flowed freely from the pipe. The sludge was apparently well digested and had very little odor.

On January 20 and on the morning of January 21 heavy rain storms prevailed in the vicinity of Lake Forest which caused an unusually heavy flow of sewage to the plant. The level of the sewage in the tank was from a quarter to half an inch above the maximum water line, and a small quantity of the sewage was passing over the weir gate placed in the grit chamber to allow excessive flow during storm periods to be by-passed directly into the lake.

At present the city of Lake Forest is contemplating the construction of a stone filter to treat the tank effluent, and also the extending of the outlet from the plant into the lake about 150 ft. where the effluent will discharge below the surface of the water.

CONSIDERATIONS INFLUENCING CHOICE BETWEEN CONTRACT AND DAY-LABOR ROAD CONSTRUCTION.*

By R. W. Acton, Division Engineer, Minnesota State Highway Commission.

The availability of responsible contractors or the possibility of developing the same should be investigated. Competent, responsible foremen and superintendents should be picked for day-labor work and given unrestricted authority and be checked up for results.

The number of small construction jobs should be reduced as far as local conditions will permit. Road work must be concentrated in order to hold low unit costs. Overhead is a necessary expense, but the more scattering the work the higher this item becomes as well as unit costs. The use of improved machinery and the employment of advanced methods of economical road construction require for the proper application of the same the concentration of work.

---

*Extract from a paper read at the annual meeting of the Minnesota Engineers' and Surveyors' Society.

The class or type of construction in reference to the topography and soil conditions of the county are an actual controlling factor as a choice between day labor and contract.

Experience has shown that when counties are properly equipped with the necessary machinery, that the light, skinning work on the prairies is more economically handled by day labor, while on the heavy work involving a real yardage that the contract system is more economical.

Soil conditions enter largely into a consideration between day labor and contract system, a striking example of the same being found in localities where it is necessary to build through ledge and boulder work, and comb the locality for sufficient material to construct a road within a cost of $2,500 per mile. This latter class of work is nearly impossible to estimate in detail, and reliable contractors must bid high to insure a margin of profit. So high must this margin of safety be placed that it is ordinarily advisable to organize a day-labor crew at once.

Whether adopting a day-labor or contract system, the expenditure should be planned several years in advance. This is especially applicable when purchasing machinery and equipment which should only be sufficient to handle the annual road expenditures. For this very reason the contract system is more often preferable on bond issue and extraordinary expenditures when the county is not justified in purchasing machinery and building up a large organization for a short period of construction.

Extreme care should be exercised by the engineer when possible in drawing up plans on road work in that the grading layout should involve the minimum outlay of equipment. Possibly this will show an apparent increase in the estimated cost, but in the actual execution of the work a strict economy will be obtained which will show in the pay rolls on day labor or in the contractor's bid on contract work.

There are three classes of road work that should not be contracted, i. e.: (a) Work that involves continuous classification; (b) Experimental work, and (c) Work that cannot be definitely specified.

In addition to these three classes of work, the writer questions the advisability of attempting to contract work which involves a grading cost of less than $500 per mile. Experience has shown that this class of work is especially adaptable for blade grader and tractor machinery. The investment in this class of machinery while being an asset to the county purchasing the same, may more likely become a liability to the contractor with the completion of his contract.

Exceptions to this $500 per mile classification might be made in reference to the small jobs which lay out of line of the day-labor crew. Such jobs, while running to high unit costs, may be more economically handled by the small local contractor.

When desirous of letting work by contract the overhead expense is a very small and profitable item when it involves the supplying to the bidders a clear and concise definite plan of the work, a definite specification, a definite quantity of work and a definite knowledge of the working conditions. These items, with an attitude of strict fairness on the engineer's part in estimating his work, will reduce unit costs on the work and insure with proper supervision very satisfactory results.

These very points are often offered by laymen and even engineers as an argument against contract work due to the expenses of overhead involved and the fact that all units of roadwork cannot be definitely specified. The indefinite unit on road work is an item which can be kept within 10 per cent of the estimated cost of the total work and by placing the same upon a unit basis for payment the matter is very satisfactorily adjusted.

In the matter of overhead expense, the writer has observed that this item is as essential to holding a low unit cost on day labor as in connection with contract work.

Certain classes of road work are especially adaptable to contract work. The general range of highway construction in Minnesota varies from $1,500 to $4,000 per mile, which may be divided into five distinct classes of work; i. e., clearing, grubbing and grading, culverts, bridges and surfacing.

Clearing and grubbing are easily contracted and should preferably be handled in this manner. These items should not be contracted separately from the grading, however. In combination a material reduction in overhead charges may be secured upon the clearing and grubbing, and a reduction in the unit price for grading will be obtained for a corresponding reason in addition to the avoidance of conflicting interest between contractors. The grading is especially adaptable for contracting in that more definite results may be obtained from an experienced management with improved methods—sufficient machinery and efficient organization—than in any other ordinary class of road work.

Culverts may be divided into two classes; i. e., portable culverts and those that are constructed in the field at the location of waterway. The purchase of portable culverts in the open market, whether concrete, cast iron or a type of the corrugated metal, should be contracted for separately by the county on a definite specification. The installation of portable culverts should in all instances be included and made a part of the grading contract.

The straight contract for monolithic concrete culverts on road work comes nearer to being a failure than any class of road work constructed. This is primarily due to insufficient supervision, failure of the contractor to realize the importance of a structure comparatively buried under ground, and the failure of supervising boards to realize the importance of first-class workmanship on this type of construction. Better results have been obtained by the county furnishing the materials and contracting by the cubic yard for placing the same in the structure.

The initial layout for machinery is so small, however, for the operation of a day-labor crew for this class of construction that when the county has any amount of the work to do it should be performed by day labor.

Bridge work as a rule affords a special problem for consideration and will not be discussed at length in this paper. Bridges are ordinarily let by contract, due primarily to the large contracting field that is open in this line of work and the failure of the manufacturers of metal to actually develop a competitive market for their products throughout the county districts.

The contracting of graveling or road surfacing is governed entirely by local conditions. When bank gravel pits are available in which the contractor may place a loading device, real economy may be obtained in the letting of straight contracts for graveling. When pits are pocketed, streaked and indeterminate, and mechanical loaders are not conducive to securing the best gravel in the pit, the letting of a flat contract is not economical for the county. Excellent results in obtaining low unit costs have been obtained by the operation of day-labor crews in developing and loading out from these inferior pits and contracting for the actual gravel haul. When the quality of gravel is of such a nature that a system of maintenance is necessary to insure a satisfactory compacted surface, the contractor's liability should cease with the delivery of gravel upon roadway. This maintenance cost is so absolutely indeterminate and is so dependent upon the quality of gravel and weather conditions subsequent to the placing of same that a contractor cannot place an intelligent bid on this item.

Provisions should be made for this maintenance by day labor.

NEW RULES GOVERNING THE HANDLING OF WATER PIPES AND OTHER UNDERGROUND UTILITY STRUCTURES ENCOUNTERED IN EXCAVATING SEWER TRENCHES IN CHICAGO.

The Board of Local Improvements of the City of Chicago has recently issued new sewer specifications for the construction of sewers by special assessment. Two new features have been incorporated in these specifications which are of general interest to municipal engineers, namely, the rules governing the handling of utilities, in general, and the rules governing water pipes, in particular, encountered in sewer excavations. We here quote those portions of the new specifications:

(5) **Rules Concerning Utilities.**—Nothing in this contract shall be so construed as to relieve any person, firm or corporation owning or using any pipes, conduits or tracks, from the obligation to maintain and protect such pipes, conduits or tracks, without expense to the City of Chicago or to the contractor building said sewer.

1. The alteration of any utility which is in the space to be occupied by sewers will be done without expense to the contractor.

2. Where excavating machines of the steam shovel type are used to excavate for a sewer 3 ft. in internal diameter or larger, except as hereinafter provided, any utility crossing the sewer trench will be removed and replaced without expense to the contractor.

3. Where excavating machines of the endless belt type are used to excavate for sewers smaller than 24 in. in internal diameter, all utilities crossing the sewer trench shall be left in place and maintained by and at the expense of the contractor.

4. Where excavating machines of the endless belt type are used to excavate for sewers 24 in. in internal diameter or larger, except as hereinafter provided, any utility crossing the sewer trench will be removed and replaced without expense to the contractor.

5. Where sewer trenches are excavated in rock, each utility company will take care of its structures without expense to the contractor, provided five days notice is given before blasting is done, and provided especial care is exercised by the contractor. This rule will apply to any utility either parallel with or crossing sewer trenches.

6. Where a utility is parallel with a sewer trench and the center of the utility is located at a horizontal distance from the center of the sewer not greater than the internal diameter of the sewer plus 4 ft., the utility will be maintained or removed without expense to the contractor. If the utility is outside of the lines of the sewer trench and is left in place, the contractor shall exercise especial care during the progress of his work, and when so directed shall leave in place such sheeting and bracing as may be necessary to protect the utility. The contractor will be paid for such sheeting and bracing in accordance with the contract prices as set forth in the specifications.

7. Where sewer trenches are excavated without the use of excavating machinery, except in rock, all utilities crossing the sewer trench will be left in place and maintained at the expense of the contractor.

8. Where utilities cross a sewer trench, and in the judgment of the Board of Local Improvements it is inadvisable to remove said utilities in accordance with those rules, the contractor will be paid the additional cost of excavation by hand under and around said utilities in accordance with the following rule:

In estimating the number of cubic feet of excavation, the length of the section will be taken as equal to the length of the sewer trench occupied by the utilities, plus 1½ times the depth of the sewer trench (no deduction being made for space between adjacent utilities); the width of trench will be the internal diameter of the sewer plus 3 ft.; and the depth will be the distance from the surface of the ground to the level of 6 in. below the inside of the bottom of the sewer. The contractor will be paid a uniform rate per cubic foot, dependent upon the extreme depth of the excavation, as follows:

Depth of excav. in ft.	Rate per cu. ft. in ct.
6	2
7	2½
8	2½
9	3
10	3
11	3½
12	3½
13	4
14	4
15	4½
16	4½
17	5
18	5
19	5½
20	5½
21	6
22	6
23	6½
24	7

This rule shall apply in the case of excavating machines of the endless belt type, which are used for the construction of sewers having an internal diameter of 24 in. or larger.

Where sewers 3 ft. and larger in internal diameter are constructed by means of excavating machines of the steam shovel type under the above conditions, the amount of the excavation to be paid for shall be in accordance with this rule, and there shall be added the sum of $5 for each lineal foot of trench as computed in accordance with this rule.

9. Where sewers are constructed in paved streets and it is necessary under these rules to remove, alter or repair any utility without expense to the contractor, the replacement of the pavement disturbed on account of such alterations outside of the limits of the sewer trench will be done without expense to the contractor. For this purpose the width of the sewer trench shall be determined by adding to the internal diameter of the sewers an amount depending upon the thickness of the walls of the sewer, as follows:

Thickness of walls of sewer.	Width of sewer trench.
3 in. or less	Internal diameter plus 3 ft.
6 in. and more than 3 in.	Internal diameter plus 4 ft.
10 in. and more than 6 in.	Internal diameter plus 5 ft.
16 in. and more than 10 in.	Internal diameter plus 6 ft.
Exceeding 16 in.	Internal diameter plus 7 ft.

10. Where sewers are constructed by means of excavating machinery all service lines from utilities to buildings will be removed without expense to the contractor, provided 48 hours' notice is given.

11. Where any excavating machine is used to excavate for a sewer, all aerial equipment belonging to any utility company, which interferes with the operation of the excavating machinery, will be removed or altered without expense to the contractor.

12. Aerial equipment which does not interfere with the use of excavating machinery will not be removed to accommodate backfilling machinery, except at the expense of the contractor.

(6.) **Rules Concerning Water Pipes.**—1. The alteration of water mains in space which is to be occupied by sewers shall be done at the expense of the Water Fund.

2. Where excavating machines of the steam shovel type are used to excavate for a sewer 3 ft. in internal diameter or larger, water mains less than 16 in. in diameter crossing the sewer trench will be removed and replaced at the expense of the Water Fund.

3. Water mains 16 in. in internal diameter and larger crossing the sewer trench will be left in place and supported during construction at the expense of the contractor.

4. Where excavating machines of the endless belt type are used to excavate for sewers, water mains will be maintained at the expense of the contractor.

5. Where sewer trenches are excavated in rock, the Bureau of Engineering will take care of the water mains at the expense of the Water Fund, provided five days notice is given before blasting is done, and provided especial care is exercised by the contractor. This rule applies to water mains either parallel with or crossing sewer trenches.

6. Where a water main is parallel with a sewer trench and the center of the main is located at a horizontal distance from the center of the sewer, not greater than the external diameter of the sewer plus 4 ft., the water main will be maintained or removed at the expense of the Water Fund.

Where such a water main is at a greater horizontal distance from the sewer, the contractor will be liable for any damage done to the water main.

7. Where sewers are constructed in paved streets and it is necessary under the foregoing rules to remove, alter or repair water mains at the expense of the Water Fund, the replacement of pavements disturbed by such alterations outside of the limits of the sewer trench will be done at the expense of the Water Fund. The width of the sewer trench will be determined in accordance with Rule No. 9 concerning utilities.

8. Where water mains cross the line of a sewer, and in the judgment of the Board of Local Improvements it is inadvisable to remove said water main in accordance with these rules, the contractor will be paid the additional cost of excavation by hand under and around said water main in accordance with Rule No. 8 concerning utilities.

9. The contractor shall ascertain for himself the existence and location of all water service pipes which may be encountered during the construction of this improvement. Where water service pipes are removed, cut or damaged in any way on account of the construction of this sewer, the contractor shall at his expense at once cause the water service pipes to be replaced or repaired. In no case shall the contractor receive extra compensation, in any form, for the removal, maintenance, lengthening, repairing or replacing of extra labor involved on account of water service pipes encountered. The contractor shall not shut off the water service pipe from any consumer for any reason whatever for a period exceeding six hours. Violation of this rule by the contractor will result in the water supply being re-established at his expense.

These provisions impress the editor as being very important. Without doubt they will operate as a strong stimulus to the use of trenching machines in city streets and a considerable saving in cost is sure to result therefrom.

Mr. Cicero D. Hill is Engineer of the Board of Local Improvements and Mr. George C. D. Lenth is Assistant Chief Engineer of Sewers. We are indebted to Mr. Lenth for the information here given.

Engineering and Contracting

Devoted to the Economics of Civil Engineering Design
and to Methods and Cost of Construction

EDITORS
H. P. Gillette C. S. Hill C. T. Murray S. C. Hadden C. W. Malcolm

Volume XLV. CHICAGO, ILL., MARCH 29, 1916. Number 13.

MOTOR TRUCK ADVERTISING FOR CONTRACTORS.

The motor truck builder gives evidence of being in something of a quandry how to appeal by advertisement to the contractor. This uncertainty is not expressed by word so much as by action. His advertising is tentative. His advertisements are "made over" from those which he has found to appeal to the merchant. Often they are the fashion plate stuff with which the pleasure car maker infatuates the limousine trade. Occasionally they are habilitated in terms and figures supposedly of the currency in which the contractor reckons but really a base counterfeit. Rarely they present a legitimate demand on the attention and interest of the contractor. These last are the exceptions and they are miserably few. Altogether dubity prevails and finds unmistakable expression in contractors' motor truck advertising.

Motor truck makers we imagine are not unmindful of the advertisement faults indicated. To perceive a fault is, however, much simpler than it is to devise an effective corrective. The editor makes no claim to exceptional possession of curatives but there are evident to him certain things which a contractor's motor truck advertisement should not be and also certain other things which it should be. To note these things may not be without service to the motor truck maker and consequently to the contractor. Service to the latter is of first consideration and no less so to the motor truck builder than to the engineering contracting journal. Without the contractor's co-operative interest full community of trade relations is an unattainable goal.

The contractor is predisposed in favor of the motor truck. This may not be the conviction obtained from their advertising intercourse with contractors by motor truck makers but it is truth. For one reason the contractor has not failed to be attracted by the economy records of the motor truck in commercial haulage. These records have impelled in him a desire to advantage himself by similar economies in his own transportation work. Again he is predisposed to consider the motor truck by his growing realization of the increasing place occupied by mechanical devices in construction processes. By one who has not followed the development of construction methods for a period of years, the influence of this last factor is likely to be underestimated. A score or even ten years ago the contractor was comparatively unresponsive to the appeal of the machine for a part in his construction operations. Now he is mentally receptive toward all reasonable offerings of mechanical ways of performing work. In view of the facts rehearsed the motor truck maker has in the contractor generally one favorably inclined to become a customer.

But while the contractor has learned during a score of years the lesson of the power of the machine for construction work he has also learned caution in investment in such devices. To a far greater extent than he feels was justified he has borne the development cost of these machines. It has been the rule, proved by some exceptions, that machines for construction work have been placed on the market in a very unperfected form. The contractor has bought them and proved their defects to the maker, who has profited from the lesson and made improvements. Then the contractor has bought again and demonstrated remaining faults in turn corrected by the manufacturers. In this wise the work has gone on until the result was a durable efficient device profitable to its user and its maker. There is no discredit to anyone perhaps in this condition; all machines must evolve from crude form to perfect form and the process is unending. Actual use is the acid that exposes the flaws and in machines for construction work the contractor has been burdened with the cost of making the test. Whatever the ethics of this practice may be it has been the practice and it has made the contractor wary of sales arguments and advertisements in the appeal of untested devices for his money.

The preceding considerations bring us our first suggestion in formulating an advertising appeal to contractors to use motor truck haulage. This suggestion is: Convincing demonstration that the motor truck has attained a sure operating efficiency as a mechanism—that it is not still in an experimental stage of development. To make convincing demonstration of this fact to the contractor requires evidence that will have meaning to the contractor. Intricate and highly technical differences in qualities of materials and design of details have little meaning. The contractor is not an expert in machine design and knowing it he is perfectly willing to accept as fact that the motor truck builder has known how to solve his mechanical problems. He is convinced that this object has been reasonably perfectly attained when he has evidence that the truck mechanism functions well and stands up under hard service. Convincing demonstration of mechanical efficiency must for the contractor be working records under service conditions—figures that show endurance, continuity of service, and reliability of operation under all vicissitudes of weather and roads and handling.

Motor truck advertising to appeal to the contractor must never depart from full realization that contractor's haulage is distinctive. It is not like mercantile delivery, road conditions, routing conditions, loading conditions, operating conditions in general are different. Quoting operating costs of city delivery of coal or merchandise of other sorts is, therefore, offering the contractor counterfeit currency and he knows it and is repelled instead of attracted. Again such operating costs more often than not fail to include charges which legitimately belong on the debit side and this the contractor also knows and his prejudice and disbelief are accentuated. Advertisement records of operating costs of motor trucks must to convince contractors be costs of motor truck service on construction work and must be inclusive. If, lacking construction work costs, costs of city delivery of merchandise by motor trucks are employed the degree of their application to construction work motor truck haulage must be frankly estimated.

Construction work conditions are in the mind of the contractor when he turns to consideration of motor truck haulage. Further, generally, the conditions of some specific work of construction are in his mind. Facts about motor truck haulage to interest him must be in terms of the conditions in mind. He does not want laboratory records. He knows that he cannot expect level, paved, city street loads and speeds and low running costs over hilly country roads; what he wants to know is what loads and speeds and running costs he can get. He wants to know these values when the road is muddy as well as when it is dry; when it is sandy as well as when it is hard. He wants to know what space is required for motor truck trackage and for turning and manoeuvering motor trucks and what effect the ground conditions have on these requirements. He wants to know what conditions of shelter and care are demanded, not those that are ideal but those that will serve without material detriment to truck operation. These are not all his desires for knowledge but they indicate its character. Specific statements are wanted—statements that recognize the contractor's work conditions and not those of the city department store.

How can these indicated requirements of forceful contractors' motor truck advertisements be met? The first requisite is a change of viewpoint by the advertiser. We are disposed to feel that this is the main thing which is greatly needed. A mental review of the records of motor truck haulage experience and costs which have passed under the editor's eye inclines him to believe that data capable of use in advertising convincing to the contractor are available. To determine to cast aside the revamped pleasure car advertisement, the back cover polychrome and the harmoniously worded generality is the greater task.

SOME ADVANTAGES OF ENGINEERING REPORTS AT THE END OF CONSTRUCTION.

A prominent engineer writes us substantially as follows: Engineers should always prepare a descriptive report on work completed, containing a historical outline of the inception and development of the project, an account of construction and experiences, and a clear statement relating to operating methods that should be followed in order to maintain the works in proper condition. Our correspondent adds that in his capacity as engineer for state bureaus he has frequently felt the need of such reports, and he has also observed the need of such reports in the hands of local authorities, though such authorities did not seem to appreciate the aid to be had from reading reports of this character. In the few instances where such reports are available, and there are few in this section of the country, they have proved to be of very great value.

The editors have urged, on many occasions, that designing engineers maintain an active interest in their works after they are placed in service. The engineer benefits by this course and so does the plant. The preparation of such a report as our correspondent suggests is the logical way in which to begin this form of observation and advisory supervision.

The designer knows better than anyone else how a plant is intended to operate. He should write out instructions governing procedure in operation for the guidance of the operator. Operators change frequently —much more frequently than the works in their charge. Such a set of instructions will have value throughout the life of the plant they cover. It is, of course, obvious that certain minor changes in operation procedure will naturally be made from time to time, but the general rules laid down will not be subject to change if they are based, as they should be, on fundamental principles that do not change. Such rules for the guidance of the operator have their greatest usefulness in the municipal field.

Can engineers afford to make such reports? Is it worth their while? Both questions will arise and both should be answered in the affirmative. The need of such reports is readily explained to the set of officials in office at the end of construction. In many cases the engineer can get another fee, small but easily earned, by carrying out the suggestions here made.

Not all engineers will adopt these or any other suggestions. Those who do will come into possession of a valuable business-getting device. The editor has demonstrated that fact in practice. The engineer who agrees to visit at stated intervals the plants he has designed, to see how they are operating, is in a stronger position than the one who makes no such agreement.

LATEST MILWAUKEE SEWERAGE REPORT GIVES MUCH INFORMATION ON ACTIVATED SLUDGE PROCESS.

The second annual report of the Sewerage Commission of the city of Milwaukee is now published and ready for distribution. It is a report of very great value to all sewerage engineers. Its greatest interest and value lies in those considerable portions of it which relate to the experimental studies which have been made on the activated sludge process of sewage treatment. There are many tables and diagrams giving the results of the experiments, and these are supplemented and explained by an extensive and well-written text. It is not an exaggeration to state that every American engineer interested in sewage treatment should personally obtain or make sure that he will have access to a copy of this admirable report. We feel warranted in making this suggestion, for we understand the Milwaukee Commission is willing to send copies to engineers and others who have a technical interest in the matters covered.

During the past year the engineers and chemists of the Milwaukee Sewerage Commission have given most freely of their time in reporting by letter, by articles to engineering journals, and by papers before societies, the results of their experimental studies of the activated sludge process. This service has been highly appreciated by the engineers of the country. The report just issued summarizes all that has previously been published on the subject and contains a very large amount of heretofore unpublished specific information. In a word, it records all that the Milwaukee corps of experts has learned about activated sludge.

The report also deals with the design and construction of intercepting sewers and gives the conclusions reached as to the value of the numerous processes of sewage treatment tested out at the Jones Island experiment station.

SERIOUS RAILWAY CONGESTION.

Congestion of delivery facilities in the East has reached such an acute stage that the Middle West is now seriously affected by it, in fact congestion on trunk lines already reaches as far west as Chicago, and is extending. Although the Interstate Commerce Commission and the American Railway Association are both active in suggesting and putting into effect remedial measures the co-operation of every shipper is needed at this time. Engineers and contractors have a vital interest in the present situation, as construction operations will be greatly impeded unless transportation conditions are soon brought back to normal. The contractor who, in bidding for work, does not take into consideration possible delays in the delivery of equipment and materials is assuming unwarranted risks.

ENGINEERING INSTRUCTION TO BE CONTINUED AT M. A. C.

Engineer graduates and other friends of the Michigan Agricultural College will be glad to learn that instruction in engineering is to be continued at that splendid institution despite the fact that the engineering buildings were entirely destroyed by fire on March 5. The editor was somewhat fearful that the agitation to discontinue engineering instruction at M. A. C., by consolidating the engineering departments with those at the University of Michigan, might be revived at this juncture, but we are pleased to learn that there has been no interruption to instruction and that plans are under way for the rebuilding of the plant recently destroyed. With the erection of these new buildings the discussion of such consolidation should be closed and not reopened again. The men who are giving their energies to the upbuilding of an engineering department of the first rank at M. A. C. are entitled at least to the assurance that they are building a permanent institution. They should be spared the annoyance of the periodic appearance of this consolidation ghost.

It must not be supposed that we seek to cast any sort of reflection on the engineering college of the University of Michigan—that is farthest from our purpose. The great State of Michigan is surely large enough for two similar engineering colleges—quite as much so, for example, as the States of Iowa and Pennsylvania.

That the spirit which built a great institution from humble beginnings in the virgin forest, 60 years ago, is not dead was forcefully shown by the fact that all engineering class work began promptly in temporary quarters on the day following the recent disastrous fire. Our admiration and best wishes go out to the engineers at M. A. C.

A TEMPTATION TO FALSE ECONOMY UNDER THE COMMISSION FORM OF GOVERNMENT.

From several quarters the complaint has arisen that a serious fault in the commission form of government exists in the temptation to discharge experienced employes to save their salaries while their duties are nominally assumed by one of the commissioners. This form of economy is likely to be more apparent than real, though this is not necessarily the case. At the outset it should be noted that a municipal corporation, fortified with the taxing power, is not justified in resorting to the extremes of entrenchment sometimes enforced by circumstances on private business corporations. The latter form of corporation may be forced into a nickel-saving, dollar-losing form of economy which the former can easily avoid by exercising its taxing powers. There has been a vast amount of talk about running a city on business principles, and about managing the city's business by the same methods employed in private business enterprises. This is all very well when done consistently, but the municipal corporation should not blindly copy some of the procedures forced upon private corporations.

An interesting illustration of the point under discussion has just come to hand. Not a great while ago a certain city installed a water filtration plant. A trained engineer represented the filter company during construction. He is a thoroughly competent man. He remained in charge of the filter plant following its completion and was made superintendent of the entire water department. He did a great deal to improve the system, and his work was highly appreciated by competent critics. Then came an election. A man ran for the office of commissioner of public property on an economy platform. After the election he redeemed his pre-election pledge to assume direct charge of the water department and to discharge the highly paid superintendent. The deposed superintendent had been receiving $2,400 a year. The commissioner is not an experienced water works operator.

Under such a set of circumstances it is not difficult to see that while there is an apparent saving of $2,400 a year there may be an actual loss much greater than that figure. This loss may be made up of three principal elements: higher maintenance and operating costs, poorer service and a poorer grade of water. The first is readily evaluated, the other two are not, but they may run into much money in a year.

In general, unless the commissioner is a trained and experienced engineer, he is practicing doubtful economy when he assumes the duties of such a man to save the latter's salary. This is a backward step in municipal government, though taken under the cloak of a new form of city government.

THE ATTITUDE OF THE EMPLOYED ENGINEER TOWARD THE UNEMPLOYED.

For some years the editor has been under the impression that the attitude of the employed engineer toward his less fortunate brother is not all that it should be. Understand, we have no sweeping indictment to lodge against the majority of engineers in this connection. We have observed many cases, however, where the employed engineer was indifferent to the fact that other engineers were out of employment. We have observed, also, a tendency for the one class to look upon the other with something closely akin to contempt. This may be human nature, but if it is, it is one of the manifestations of selfishness which sometimes discourages the best friends of the well-known human race.

While the natural impulse of the employed is to feel a sense of superiority over the man out of a job, the engineer above all men can least afford to take such an attitude. Engineers outlive many jobs before they outlive their usefulness. Many engineering positions flourish for a time, like the famous flower of the field, and then go out of existence. Therefore it is not a reflection on one's ability to be an unemployed engineer—it is merely a misfortune.

What would we have employed engineers do? Of course they cannot create jobs, just to be good fellows, but they can exert themselves a little bit more in bringing good men and good jobs together. It is a tantalizing fact that the man who has a job usually sees chances to get others, while to the man out of a job it sometimes appears that the last job has been filled by a man who expects to hold onto it while life lasts. In view of this fact, isn't there enough of a fraternal spirit among engineers so that the man who is not attracted by a vacant position, of which he has knowledge, will bring it to the attention of another man who might be? Of course, this sort of thing is being done right along by some engineers; our point is that all should interest themselves in this matter.

Some engineers, who do the hiring and firing for corporations, are reluctant to let the fact that they want another man become too widely known. They fear they will be swamped with applications. We are not in sympathy with that attitude. It isn't necessary to grant an interview to every applicant. In fact, the best way to select a man from a group of applicants is to ask each to write a letter stating his qualifications for the position sought. A very few minutes will enable the employer to run through these letters and select the man he wants; then a brief interview will close the deal. At the very least the employed engineer should not deny the right of the unemployed to make application for a position. The man on a salary, even on a big one, can't afford to be too cocky in these matters. He may be out next week, himself, and that for no fault of his.

In an effort to square practice and preaching we announced, a few weeks ago, that we would publish advertisements of vacant positions without charge. We have just had a letter from an Oklahoma corporation giving their experience with the plan. They received over 20 answers to the advertisement, and the locations of the applicants range all the way from Washington to Alabama, and from Minnesota to Texas. A suitable man was selected from these applications.

One of the maxims of the playground which are worth carrying through life is: Give the other fellow a chance!

EDITORIAL PARAGRAPHS.

The most prominent sanitary engineer in this country recently stated, publicly, that he was forced into that branch of engineering at a very early stage of his life, at a time when it had anything but attractive features. It was the necessity of earning his living in the position he was holding which caused him to take an interest in it, because he thought that inasmuch as the subject of sewage disposal was rather disagreeable nobody cared to look into it. However, he soon saw some directions in which if an engineer turned some of the scientific information he had acquired, there was good reason to hope that much could be done in the way of gradually turning a subject which was most offensive 50 years ago into one which is now a credit to civilization. He expressed pleasure that he has lived long enough to see that these somewhat vague hopes held in his youth, have been realized. He, more than any other man, has led in this development. This accomplishment is all the greater because the genus homo is normally and instinctively less concerned in this subject than some of the so-called lower animals, notably the felus domesticus.

Consider the expert. Webster says that an expert is one who has skill, experience, or extensive knowledge in his calling or in any special branch of learning. The term ordinarily connotes relative and not absolute knowledge. Thus the expert knows more than the inexpert though the exact knowledge of both be small. The individual is expert in one thing, at best, and is inexpert in everything else. Therefore the community is always inexpert about any matter before it. This impresses us as unfortunate when we are doing the experting but on all other occasions it strikes us, if we think about it at all, as being a saving condition. The expert tends to throw off his governor belt and run away. Think what would happen if all the experts could have their way at the same time. The result would be appalling. If the army experts had their way, for example, we would probably be toting a musket this minute. If expert sanitarians had had their way 20 years ago every city would have installed a septic tank to treat its sewage. And if this had come to pass the sanitarian would now be as extinct as the well-known dodo. All of this leads to the conclusion that it isn't so unfortunate after all if the expert can't always run things.

A technical journal editor doesn't always feel complimented when he is referred to as a newspaper man. There is a measure of praise and a degree of condemnation in the term. As applied to the editor of a dignified professional journal the use of the term "newspaper man" reminds us somewhat of a term once employed in the cow country. Perhaps you know what it was. Sometimes it was used to express playfully, and in a thoroughly masculine manner, certain feelings of admiration, comradship, etc., for the one to whom it was applied. Again it was used as a term of reproach, of disapproval or of the deepest contempt. Because of the fact that it was complimentary if taken in one sense and uncomplimentary if taken in the other, a simple eye and mouth test was devised so that the one addressed might know in what sense he was to take the word. Thus if the word was spoken with a smile everything remained serene; in the absence of the smile the "soonest" of the two cowmen "creased" or "plugged" the other. Do you follow us? Everything depends on how a term is used.

A few years ago somebody said: "Don't knock—boost." Few expressions have had a longer vogue. Like many other good things the boosting was carried too far. It developed to the point where an amiable optimism reckoned self-deception a virtue. Happily the tide of senseless boosting is receding and this is nowhere so evident as in our cities. Not long ago it was considered an unforgivable transgression of the civic proprieties to admit, in certain cities, that a communicable disease was prevalent in the community. Then, according to the booster's creed, to tell such a hideous fact scared business men away and gave the town a bad name. Now it is realized that to tell the facts in such a case is to put the citizens on their guard and to prompt them to help the health authorities isolate the existing cases. Now it is realized that only the disposition to cover up the truth about such things is permanently damaging to a city's reputation. Irrational boosting is no longer a virtue—it is simply foolish. It is also futile. The sound and substantial town is the one which dares to face the truth about itself. And so it has come about that a man can offer a constructive criticism without branding himself a knocker.

The upper limit in inane bidding was attained recently at a bridge contract letting in Iowa. One bidder offered, in his bid, to build the bridge for $500 less than the lowest figure submitted by any of his competitors. A smart trick, assuredly—one which, if peristed in, will speedily lead to bankruptcy. Oh, well, a man who will bid like that is only one jump ahead of the fool killer, anyhow.

SOME MAINTENANCE COST COMMENTS ON NEW YORK STATE ROADS.

To the Editors: Why do road engineers supply, and editors publish and seriously comment upon such utterly worthless stuff as that printed on page 240 of your issue of March 15, under the title "Some Maintenance Costs of New York State Roads"? I single this out only because it is a fair sample of much of the highway literature of the day; and it seems time to protest. It will hardly be denied that in no other department of engineering work is there so much indefinite statement and loose reasoning.

It is easy, and would doubtless be true, to say that a sheep-trail costs less to maintain than a turnpike, but does the statement add anything to our knowledge of the relative utility of various kinds of highway? Is it really necessary at this late day to call attention for the ten-thousandth time to the fact that the cost of maintaining a highway is dependent upon a whole lot of elements, a knowledge of which is absolutely necessary in order to judge even approximately of its relative durability or economy.

Of what value is a bald statement that the average cost of maintaining certain brick roads was $141 per mile while the average cost of maintaining certain cement-concrete roads was $129 per mile?

Do such writers and editors really delude themselves into the belief, or hope to lead others to believe, that the cost of maintaining a roadway is independent of such factors as character of sub-foundation, specifications, quality of materials used, skill or thoroughness of work, and, above all, age of the pavement, and kind and quantity of travel sustained? If not, why do they so often fail to give us at least some idea of the comparative magnitude of these factors when purporting to describe the qualities or economics of highways? Those who were in the paving business thirty years ago were often "up against" such statements from intelligent (?) clodhoppers, as "There's Front Street paved ten years ago with granite, and Back Street was paved at the same time with asphalt; the former is worn out, the latter is still good; therefore," etc. Not a few of our highway engineers seem not yet to have gotten beyond this primeval formula of reasoning.

Why cumber space and waste the reader's time unless sufficient data can be given, at least approximately, to enable him to form an intelligent opinion? W.

March 17, 1916.

(At least one good reason why editors do well occasionally to publish "stuff" of the kind referred to is furnished by this letter. When a highly qualified engineer "lets himself loose" as in this instance, editors and road engineers and other readers get a fresh grip on the verities. Originally the editor was rather dubious of his excuse for publishing the little article criticised but he now feels wholly gratified at the decision he made.—Editors.)

A Correction.—The article in our issue of March 15, 1916, entitled, "Formulas for Determining the Pressures of Piles Supporting Masonry," should be corrected as follows: Line 15 on page 246 should read "and formula 7 to"; and line 38 on page 246 should read "$S = \frac{3}{1} = 3$ ft."

Shipping Automobiles by Gondola.—The shortage of automobile freight cars has given rise to numerous emergency measures originated by the traffic departments of automobile companies. Charles Shaar, traffic manager of the Packard Motor Car Co., has partially solved the problem by the erection of sturdy superstructures on railroad gondolas. These housings protect the shipments practically as well as the regular automobile freight cars. When the covered gondola reaches its destination the dealer is instructed to bill the superstructure back as a carload of lumber, tar paper, etc., which it really is. In this way the car is returned quickly to the factory and can be used for other shipments.

NOTES ON EARTH DAM CONSTRUCTION.*

By G. C. Habermeyer, Consulting Engineer, Aurora, Ill.

In the southern part of Illinois many cities and towns use the waters of small streams as sources of public water supplies. It is generally necessary to build a dam to hold back part of the flood flow in order that it may be used later when there is little flow in the stream. When a long dam is necessary earth is the cheapest material to use for construction.

When an earth dam is built over gravel, sand or seamy rock leakage through this material may be reduced by driving piling through it or by excavating a trench through it and filling the trench with clay or concrete. Water is usually encountered in such a trench making it difficult to fill the excavation with good concrete. The water may be pumped out and short lengths of trench filled rapidly after pumping is stopped; water may be allowed to run along the sides of the trench to the pump or pumps or the concrete may be placed under water.

Short lengths mean slow work. Allowing water to run along the sides of the trench may leave a passage through which water may flow to the most pervious place through the wall. In placing concrete under water there is a chance of undetected poor work.

A concrete wall is often used and carried up to above high water line in the reservoir in order to make the dam more impervious and to prevent animals from burrowing through. When a concrete wall is not used the most impervious material available is placed in the center or upstream part of the dam. The sod from borrow pits is usually wasted and the material just underneath the sod placed in the downstream part of the dam.

In southern Illinois the best material available is often close to the surface and is of considerable depth so that nearly all of the dam may be built of it. At Paris, Ill., when a new borrow pit was opened some surface material, a clay loam, was placed in the dam near the top. It saved wasting and was good soil on which to grow blue grass. Material was hauled over this loam to another part of the dam. The loam could not be compacted and it was necessary to cover it with clay to secure a good driveway.

Earth should be deposited on a dam in thin layers. The mistake is sometimes made of using thick layers and rolling with a very heavy roller. With this method the bottom of the layer is not compacted well and the top is made so hard that a plane of leakage may be formed. Good results may be secured by compacting a fill with the traffic of the teams making the fill. At Paris wagon loads of earth were dumped in rows 5 ft. apart parallel to the axis of the dam, with loads about 12 ft. apart in a row. All teams dumping within 150 to 200 ft. of the end of row farthest from borrow pit traveled to the end of the row. All other teams turned after dumping. The loads were leveled off with a grader.

I think few contractors would object to dumping loads far apart after they have tried it. A better driveway is secured and the grader is not apt to be very busy.

In building a dam hauling by dump wagons is cheapest in most cases. With a good borrow pit wagons may be cheaply loaded with a wagon loader pulled by a traction engine. In good work while traveling along one side of a borrow pit a wagon can be loaded every 30 seconds in a distance of 50 ft. Fifty feet length and 50 seconds' time will be required to turn at end of pit. These figures will vary with different machines and with conditions. To haul with mules from borrow pit to place of dumping load when conditions are good will take one minute for each 200 ft. of travel. Teams must sometimes drive past the wagon loader and fall in line to wait their turn to load. Estimating that one minute is taken in driving beyond point of loading gives an average time for a trip of one minute plus one minute for each 100 ft. from center of borrow pit to center of fill. Delays for watering and coaling will be about 30 minutes in a day.

One other delay is caused by not having just enough teams and wagons to keep the loader busy. The proper number varies with length of travel, kind of material, wetness of material and condition of road traveled; all of which may vary from time to time. Teams may sometimes be given other work but the adjustment cannot be kept perfect. A wet borrow pit slows up work. When a clay borrow pit is wet it is often necessary to have teams help turn the engine at the end of the pit and it does not take much water to make turning almost impossible. Moist clay in a borrow pit is compacted by the traction engine and much of it is plowed up and loaded in large lumps. It is difficult to compact this lumpy material close to concrete work.

When a borrow pit is so wet a wagon loader cannot be used the dirt may be moved with scrapers. Scrapers are also used where borrow pits are too small to use a loader economically, for very short hauls, as in cleaning off a dam site or borrow pit and in places difficult to reach with wagons.

---

*Paper before joint meeting of Illinois Section of American Water Works Association and Illinois Society of Engineers.

WRECKING CONCRETE STRUCTURES WITH EXPLOSIVES.*

Although the destruction of plain concrete and reinforced bridges in warfare is comparatively simple, the process of wrecking such bridges when it is desired to preserve the reinforcement is more complicated. Civil engineers have frequently used compressed air or electrically driven tools for wrecking purposes as they are less accustomed than military engineers to the use of explosives. Even in civil practice the end is more easily and cheaply attained by the use of explosives, and it is possible to preserve the reinforcement as thoroughly as when mechanical methods are used.

Since concrete has a very low tensile strength, mass concrete is very readily ruptured by the expansive force of explosives, especially of high explosives, which give rise to such intense dynamic stresses. The concrete usually breaks into a few large pieces, which may be hurled to a considerable distance. Mass concrete bridges are easily destroyed by destroying such parts of the structure as will allow the rest to collapse under ordinary static load. Thus small charges of high explosives may be fired in holes drilled in the concrete. Structures of great military importance, such as bridges and dock walls, are often provided beforehand with mine chambers and mining passages. In the second place, charges of high explosives may be fired after attachment to the outer surface of the structure. This method is rapid, but is wasteful of material. It is always adopted where the structure lies under water, where the preparation of bore-holes would be too difficult.

Reinforced concrete withstands sudden tensile stresses much better than plain concrete. Thus all recent tunnels for testing the safety of mining explosives have been constructed of reinforced concrete. The experimental tunnel at Lievin, in France, constructed with an internal resistance of 4 kg. per square centimeter (228 lb. per square inch), has withstood 1,229 explosions without internal injury, whilst externally the finishing coat has been dislodged here and there.

The method to be adopted therefore involves the destruction of the concrete at statically important points, followed by the cutting of the reinforcement by explosives, sawing, or the oxy-acetylene flame. It is found that the concrete in reinforced structures is shattered into small fragments.

The preparation of bore-holes in reinforced concrete structures is usually troublesome on account of the uncertainty of the position of the reinforcement, and where mine chambers have not been provided beforehand, charges attached to the surface are mostly employed, usually in the form of several parallel lines of charge.

The following rules are in use for determining the charge:

Where numerous light charges are used, so as to secure a great effect with economy of explosive, the load L in kilograms (2.2 lb.) is given by the formula

---

*Extracts from article by P. W. Scharros in Beton u. Eisen.

$$L = g.o.w^3,$$

where g is the charge coefficient (7 for black powder and 3 to 5 for high explosives), o is the tamping coefficient, and w the distance of the charge from the nearest surface.

Where few heavy charges are used, as when quickness is more important than economy, the formula is

$$L = g.q.o.w^3,$$

where q is a coefficient depending on the form of the crater to be produced.

Where charges attached to the surface are to be employed, the charge per metre (3.28 ft.) length of the structure is

$$L = g.q.w^2.$$

Where internal charges are to be used in reinforced concrete they may be two or three times as great as in plain concrete.

THE SERIES OF LECTURES GIVEN TO FIREMEN AT PHILADELPHIA WATER PUMPING STATIONS.

As stated editorially in this journal, several weeks ago, a series of notices or lectures were given last year to firemen at certain stations of the Philadelphia Bureau of Water. The editorial called for an expression of opinion from our readers in the water works field as to the advisability of publishing these in this journal. Several readers have urged that we publish the lectures and we are, therefore, guided by the wish so expressed. While there isn't anything particularly original about these notices, the attempt was made in compiling them to present the matter given in a way that would appeal to the average fireman. The results secured in Philadelphia were good. The lessons here given are valuable, also, as showing an effective way of instructing employes. For this information we are indebted to Mr. Carlton E. Davis, Chief of the Bureau of Water:

I.

This paper is the first of a series of lessons on the theory and practice of combustion as applied to modern boiler room practice.

Combustion results from the ignition of a chemical mixture of carbon and oxygen. The carbon is contained in the coal in varying forms and quantities, depending on the kind of coal. Anthracite coal contains a higher percentage of carbon than soft coal.

We are mostly concerned in the burning of soft coal, therefore we will consider this kind of coal only. Soft coal will contain in varying quantities, depending upon the quality of same: Moisture, volatile matter, carbon, ash, sulphur and hydrogen.

When coal is burned on our grates the first to be distilled off will be the moisture, the next will be the lighter gases or hydro-carbon and volatile matter; after which the carbon will burn, leaving the ash or waste.

II.

Chemistry of Combustion.—In order to understand this subject thoroughly it will first be necessary to know the meaning of different chemical symbols used in connection with the various chemical actions resulting from the burning of coal on the grates.

An Element is a substance that cannot by any known means be further separated; for instance, carbon, gold and silver in their pure state are known as elements. They cannot be further separated.

A Compound is a chemical combination of two or more elements—i. e., water, for example, is a compound because it can be separated by electricity or the application of heat into two gases that have no resemblance to the water whatever. Water is a chemical compound of hydrogen and oxygen in proportions of two to one.

A Mixture.—Two or more substances, either elements or compounds, may be mixed together and yet not combine to form a new substance—i. e., air is a mixture of nitrogen and oxygen (77 parts, by weight, of nitrogen and 23 parts, by weight, of oxygen). The two gases are not combined chemically; they are simply mixed.

By referring to the list below you will find the elements with their chemical symbols that are frequently used in reference to combustion:

Elements.	Symbols.
Hydrogen	H.
Oxygen	O.
Nitrogen	N.
Carbon	C.
Sulphur	S.

Any of the above elements will combine under favorable conditions to form either a compound or mixture.

$$C + O = CO.$$
$$C + 2O = CO_2.$$
$$2H + O = \text{Water.}$$

In the last paper on this subject the different elements entering into the study of combustion were shown. In this paper we will see how chemistry is practically applied in the furnace.

An element will in most cases combine with some other element to form a compound or mixture. The most familiar elements with which we are brought in contact in the boiler room are carbon, oxygen, hydrogen and sulphur.

In our plant the coal, which contains all or most of these elements, is fed to the magazine, from which it is pushed by the coal pusher on the coke plate. Here it meets with the heat of the furnace and undergoes certain chemical changes. The heat evaporates the moisture, which changes to steam, and in passing over the intense heat of the lower fire dissociates the H from the O, and the H forms a hydrogen gas. This hydrogen gas again takes up oxygen and burns, and the product of this combustion is water.

The heat resulting from the combustion of a pound of hydrogen is 62,000 B. T. U. A British Thermal Unit, or B. T. U., is the amount of heat required to raise the temperature of 1 lb. of water 1°. Example: If we take a pound of water and place a thermometer in it and find the temperature to be 62°, then take a sample of coal in a powdered state and put it in a bomb and place the bomb in the measured quantity of water, and by some means, say an electric current, explode the coal, all the heat generated by the combustion of the coal will be transferred to the water. If the temperature of the water rises to 63° we can say that one B. T. U. has been expended, or if the pound of coal has been used and the temperature of the pound of water raised 14,000°, we can say that the coal contains 14,000 B. T. U. per pound. In the laboratory, instead of using a pound of coal and a pound of water, they use a small quantity, say a dram of coal and a pound of water, and find the B. T. U. by calculation.

After the moisture the light gases are then distilled off. By light gases we mean the gases that distill at a low temperature. These are hydro-carbons, or marsh gas, tarry vapors, methane, etc.

These light gases take up O from the air and form an explosive mixture, which burns to either CO or CO_2 and H_2O. The carbon in the gas will take up O. If the carbon unites with one atom of oxygen the result will be CO, the heat of combustion of which is 4,400 B. T. U. If the carbon takes up two atoms of O, then the result will be CO_2, the heat of combustion of which is 14,600 B. T. U. per pound of carbon. CO can be brought to a further combustion if more air is admitted, or by adding one more atom of oxygen. CO is the stuff they make at the U. G. I. to sell you at $1 a 1,000 cu. ft.

Now, if it pays the U. G. I. to burn coal to make CO to sell to you, why should we burn coal to make CO to push out of our stacks?

This might seem absurd, but it is no less the fact; that when you put the bar in the fire and push a large quantity of green coal down to the dump grate you distill this light gas off so quickly and in such large amounts that it has not time to take up the proper amount of oxygen, and the result is CO or unburned carbon, which goes out the stack in great clouds of smoke.

The carbon next burns off, and if properly mixed with air, and in a temperature sufficiently high, burns to CO_2, the heat of which is 14,600 B. T. U.

	B. T. U.
Carbon burned to CO_2	14,600
Carbon burned to CO	4,400
Heat lost up the stack	10,200

III.

Chemistry of Combustion.—In the last paper on this subject we found it does not pay to make CO in our furnaces to push out of the stack. Carbon monoxide, or CO, as we know, is the product of combustion of carbon with too little air supply.

We are directly responsible for making carbon monoxide in several ways. The most common reasons for this in our plant are: First, a too heavy fire bed which will prevent the proper quantity of air passing through the fire; second, too little air supply caused by slowing down the fan, closing the damper or opening a door of the boiler when the fire bed is thick; third, an insufficient temperature to burn CO to CO_2, even after a sufficient quantity of air has been admitted.

These are only the most common causes for making CO in our plant, but they will serve to show you that the essential conditions necessary for complete combustion are: First, a thorough mixture of the gases; second, a sufficient air supply; and third, a sufficiently high temperature in the fire box.

The furnace itself should be constructed to allow all these conditions to be carried out completely. For instance, if it is desired to burn the coal at a high rate and the furnace is too small to accommodate the great volume of gases generated, some of the gases strike the comparatively cool surfaces of the boiler before they have been thoroughly consumed and, there not being sufficient heat, will go out of the stack unburned.

Our department is going to great expense to give us the proper furnace—i. e., the extended front furnace or Dutch oven. The success of this furnace is in the fact of a greater combustion chamber, where the gases can thoroughly mix and burn before they strike the tubes.

While we have been brought to know the cause and effect of incomplete combustion, there is still another and even greater source of loss in furnace operation, namely, the loss due to too much air. This loss can exist by having the fire too thin, or holes in the fire, or cracks and openings in boiler setting.

IV.

Points to Remember in Operating Wetzel Stokers.—It is a mistake to pile coal in too great amounts at the mouth of the stoker. If this is done the coal is liable to roll down the inclined grates, just as a snowball rolls downhill, collecting coke as it goes along. If the coke is picked up in this manner too large an area of the grate would be exposed, permitting free air to pass through. This air would pass between the grates and not through the coal, because the air would always follow the line of least resistance. This large volume of air would lower the temperature of the furnace and destroy the draft in the fire box. Boiler temperatures will drop considerably from such a cause, will destroy the products of combustion and reduce the CO_2 gases down to a very low point. Of course, this decreases the efficiency of the boiler and the amount of steam generated. The furnace could very readily drop 15 to 20 per cent in efficiency. This is bad both for the purchaser of the coal and the fireman in charge of the boiler. It compels the fireman to handle extra coal and gives him extra work with less results.

When you put your bar in the furnace to move the coal that accumulates near the mouth be very careful to observe that you do not start the coal avalanching. Just move a small amount at a time, or simply enough to keep the grates properly covered. In this way you will find the boiler steams better, heat is maintained more uniformly and the fireman has less work to do. The boiler itself will be kept in better condition, as expansions and contractions will be reduced.

Be very careful to observe the color of the furnace. When the fire is red, it means that the temperature is too low. The best way to burn the coal is to maintain the fire at a white heat. When you look under the grate you may find a part showing dark. Such dark spots mean that there is either green coal next to the grates, or else a clinker has fallen. If it is green coal, let the place alone until the coal is burned through. If a clinker is formed, it should be loosened up with the bar.

You cannot be too careful in regulating the amount of coal supplied to the fire. Some firemen, by careful and uniform regulation, get the same amount of heat as others with 20 per cent less coal and a correspondingly less amount of work for themselves.

V.

Combustion.—After a study of the preceding article you now know what the essential conditions for the complete and economical combustion of coal are: (1) A high temperature in the furnace; (2) a thorough mixture of the gases; (3) an adequate air supply.

Now how are we to know that all these conditions are being carried out in our furnaces? We will proceed to answer by considering the conditions as they appear above.

The temperature in the furnace can be measured direct by the pyrometer. However, since we have not the pyrometer continually before us to see the temperature we must use our sense of sight and judgment. For instance, we know by sight when looking into the fire if the furnace has a low temperature. Since the fixed carbon in the coal requires a temperature of something like 1,800° to ignite it and the temperature rarely exceeds 2,500°, you will see great care must be exercised to keep the temperature up.

The temperature may be seen and known approximately by comparing the color of the furnace with the temperatures given in Table I.

TABLE I.—KEY TO METHOD OF DETERMINING BY EYE THE TEMPERATURE OF A FURNACE.

Temperature, degrees Fahrenheit.	Appearance.	Temperature, degrees Fahrenheit.	Appearance.
980	Red. Just visible.	2,010	Dull orange.
1,290	Dull red.	2,190	Bright orange.
1,470	Dull cherry red.	2,370	White heat.
1,657	Full cherry red.	2,550	White welding heat.
1,830	Bright red.	2,740	White dazzling heat.

We also know the steam pressure must be kept up, and that each pump is performing a certain amount of work. Each pump consumes so many pounds of steam per hour. Now, if we can supply the required number of pounds of steam with the least number of boilers, we know that the temperature in the furnace has to be kept at a high degree.

You will therefore see the advantage of working the boilers against the load carried. For example, suppose we run six pumps, each pump has proven by test to perform 750 HP., and each horsepower takes 15 lb. of steam, that means we must supply 67,500 lb. of steam an hour for the engines. The auxiliaries require an additional 1,000 lb. of steam, making in all 68,500 lb. of steam required to run the plant.

Then 68,500 divided by a boiler horsepower, which is 34½ lb. of water evaporated from and at a temperature of 212°. If the temperature is less than 212°, we will evaporate less pounds per hour, and if more than 212° we will evaporate more pounds of water per hour. The American Society of Mechanical Engineers has conventionally adopted a standard of comparison, which means that all temperatures must be brought to the equivalent of 212°.

Then 68,500 lb. of steam required divided by 34 (to use round numbers) will give us 2,015 boiler HP. required to supply the demand, which means that a little more than four 500-HP. boilers will do the work. We will run four boilers at rating and hold one boiler for make up. This has been recommended by, and carried out in some of the best regulated plants in America, and has proven, as our records will show, to be a most satisfactory method for us to pursue.

The mixture of the gases cannot be readily determined without the use of the Orsat or a flue gas analysis, but if the grates are free from clinker and the air spaces open in the grates, you can rest assured that the mixture of the gases with the air supply in our plant is fairly good, provided, however, that the fire is evenly spread.

The air that has been admitted can be only determined definitely by analysis of the products of combustion.

The air supply will be treated in another article on draft.

VI.

Draft.—The air required by the furnace for the combustion of fuel is supplied by the draft. There are two ways of making draft. 1. By a chimney. 2. By a fan or blower.

Natural draft is produced by the difference between the weight of a column of hot gases contained within the chimney and the weight of the same bulk of cold air. It is well known that any gas when heated is lighter, bulk for bulk, than when cool.

When the hot gases pass into the chimney they have a temperature of say 500°, while the air outside has a temperature of from 40° to 90°. Roughly speaking, the air weighs twice as much bulk for bulk as the hot gases. Naturally therefore the gas in the chimney is a little less in pressure than the outside air, and in consequence thereof the air will flow from the point of higher pressure to that of lower pressure, i. e., through the furnace into the chimney. This performance keeps up as long as any heat is in the furnace. The cold air trys to push the hot air out by the furnace route and in so doing it becomes heated when passing through the fire.

You will therefore see that the draft in a natural draft plant, such as No. 2 House, depends on the temperature of the gases, and we must keep the furnaces at as high a temperature as possible.

For example, suppose that a chimney is 150 ft. high and that the temperature of the hot gases is 500°. A column of gas at this temperature 150 ft. high and of 1 sq. ft. cross section weighs about $6\frac{1}{2}$ lb. A column of air 60° of the same dimensions weighs $11\frac{1}{2}$ lb. Hence the difference in pressure at the bottom of the chimney is $11\frac{1}{2} - 6\frac{1}{2}$ or 5 lbs. per square foot. In other words, the pressure of the draft is 5 lb. per square foot.

It is customary to express the pressure of the draft in inches of water. The pressure of the atmosphere at this altitude is 14.7 lb. per square inch and will support a column of water 34 ft. high. Then if water 34 ft. equals 14.7 lb. per square inch $34 \times 12 = 408$ in. of water, or 14.7 lb. pressure per square inch or 2,116.8 lb. per square foot. Therefore 1 in. of water equals 14.7 divided by 408 in. equals .036 lb. per square inch or 2,116.8 divided by 408 equals 5.2 lb. per square foot.

So when we say there is 1 in. of draft we mean the pressure existing in the boiler is reduced below the atmospheric pressure sufficiently to balance a column of water .036 in. high.

The draft pressure can be measured by a draft gage which in its simplest form is a glass tube bent in the shape of a letter U fitted with a scale graduated in tenths of an inch. One end is attached to the boiler furnace or stack, and the other end is open to the atmosphere. The difference in level of water in the two legs of the gage will then be the intensity of the draft.

While the U-tube is the simplest form of a draft gage, there are various makes, which, however, are all on the same principal.

The inclined tube which we use, as shown in the Blonc Meter, is merely to show a more accurate reading by causing the liquid to move a greater distance along the inclined tube for a given rise in vertical height.

Mechanical draft is produced in either of two ways, namely by placing a fan or blower between the boiler and stack, in which case it is known as induced draft because it pushes the heated gases out the stack and produces a partial vacuum, which induces the outside air to enter under the grate and through the boiler to the fan and then to be pushed out the stack.

The other form of mechanical draft is known as Forced Draft, produced either by a fan or blower forcing the air under the grate; in this case the ash pit is closed and a pressure created in it.

Natural draft has the advantage of low cost of maintenance, but having to depend on the temperature of the air and gases it is therefore influenced by climate conditions to some extent.

In the mechanical draft plant, of which No. 3 House is an example, the air supply is not influenced by atmospheric conditions. The mechanical draft is very flexible so that if it is desired to increase the steaming capacity, it is only necessary to increase the intensity of the draft, thereby enabling us to burn more coal per square foot of grate surface.

Both forced and induced draft are good; the only disadvantage in induced draft being the setting must be kept tight because the vacuum induced will allow the air to pass through any openings that may exist in the setting; while the forced draft creates a pressure more nearly approaching that of the atmosphere through the boiler.

In summing up, it will be seen the air used for combustion is entirely dependent upon the draft.

The coal burned per square foot of grate depends on the intensity of the draft. The steaming capacity may be varied by the draft pressure. With each rate of feeding coal to the boiler, there is a certain draft pressure that will burn it economically.

The Blonc Boiler Efficiency Meters with which we are familiar are nothing more than draft gages. The arrows are set according to the draft pressure that will give the most economical combustion. In other words, for the draft pressure that will admit the proper quantity of air for the complete combustion of the fuel previously determined by an analysis of the flue gas.

SAND REQUIREMENTS FOR BRICK PAVEMENTS.*

By H. E. Breed, Deputy New York Commissioner of Highways.

Many bad results in brick pavements can be directly attributed to the use of poor sands. The inconsistency of present day practice is shown by testing the cement and brick both with a fine degree of engineering precision and trusting the other material, sand, to visual guesswork.

Three different and distinct kinds of sand are used in brick pavements—concrete sand, cushion sand and grout sand. Concrete sand should be clean and have at least 80 per cent of the strength of Ottawa sand in compression. Its gradation should be as follows: 100 per cent passing the $\frac{1}{4}$ in.; 85 per cent passing the 6; 60 per cent passing the 20; 25 per cent passing the 50; and a variation of not over 5 per cent from these figures should be allowed. Sand with over 8 per cent of loam should be rejected. These may seem to be rigid specifications, but if a foundation is to serve its purpose it should be strong enough to sustain the pavement with the minimum amount of cracking.

Cushion sand should be of such a nature that 100 per cent will pass a No. 6 screen and it should not contain more than 20 per cent of loam.

Grout sand should be clean and of such a nature that it will have: 100 per cent passing a No. 6; not more than 85 per cent passing a No. 20; 30 per cent passing a No. 50; 5 per cent passing a No. 100; and it should be rejected if it contains more than 5 per cent of loam.

CHECKING EXCESSIVE WATER CONSUMPTION AT GARDNER, MASS.

The metering of domestic services was begun at Gardner, Mass., last year and will be completed in about two years. The meters are read monthly, and if a meter is found which reads more than the water registrar considers a normal amount, he sends a notice to the consumer calling attention to the fact. The form of notice, which is sent in an outlook envelope, is as follows:

The water meter at your house, ... St., shows a consumption of....................cubic feet for the month of ....

As this is a large amount of water to use and will mean a large water bill unless the consumption is reduced, we would ask you to kindly see if there are any leaking fixtures, and, if so, have them repaired at once.

Very truly yours,

GARDNER WATER WORKS.

---

*Extract from a paper read at the Pittsburgh meeting of the American Road Builders Association.

A TOWING WINCH TRACTOR FOR CONTRACTORS' SERVICE.

(Contributed.)

The special feature of the tractor illustrated is towing and hoisting winch which is attached on the rear of the tractor frame. This winch is equipped with 150 ft. of cable, and is driven from a power attachment on the transmission through a propeller shaft and two universal joints to a worm and gear on the winch shaft. The winch drum is loose on the shaft and is driven through a clutch which may be released by hand when it is desired to reel off the cable. With the motor running at 1,000 R.P.M., the cable is hauled 40 ft. per minute.

When it is desired to operate the winch, it is of course necessary to anchor the tractor itself, and to supply this anchorage a heavy sprag is attached to the rear axle so that it may quickly be dropped into position. When not in use, this sprag is carried well out of the way.

Provision has also been made so that the tractor can tow in either direction. At the rear of the tractor frame a large steel-forged towing hook is attached and a heavy buffer spring is inserted to absorb the shock of sudden starting. An automatic locking device prevents the escape of chain or ring which may be inserted for towing. Two front hooks of the twisted type are attached for use in cases where it is desirable to tow backward or to anchor the tractor in addition to the sprag.

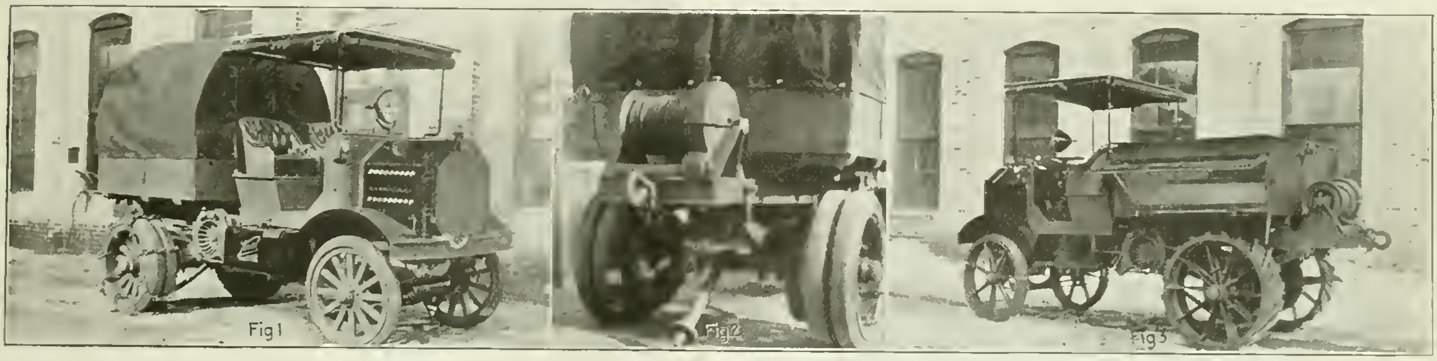


Fig. 1. Normal Tractor Body on Rubber Tired Wheels.—Fig. 2. View of Rear End Winch and Sprag.—Fig. 3. Steel Wheeled Tractor with Steel Body.

The tractor chassis is designed to support a weight of from two to four tons in any form of body which may be desired, thus insuring the necessary degree of traction and enabling the tractor to act as a carrying, as well as a hauling, vehicle. Steel wheels are also provided at small additional cost, either as a substitute for the standard rubber-tired wheels or as extra equipment, thus insuring the successful operation of the tractor even under unusually unfavorable road conditions.

The towing tractor is especially adapted to heavy work and unusually severe road conditions. For example, where the tractor is called upon to haul a heavy loaded four-wheeled trailer, or a train of trailers, up an abnormal grade, the trailer wheels can be blocked, allowing the tractor to run ahead of the load a distance equal to the length of the winch cable—150 ft. The tractor can then be anchored by means of the sprag and the 20,000 lb. drawbar pull exerted by the tractor motor through the winch can then be utilized to bring the loaded trailer or trailers to a position directly in back of the tractor. In bad going, the winch may also be used to pull the tractor or trailer up on to solid ground when either has become mired.

The winch feature also equips this tractor to perform a number of useful tasks in connection with the transporting of heavy tonnage. In the lumber field, for example, the winch can be used to pull heavy logs or timbers into place preparatory to loading, etc. Contractors can use the winch for wrecking building, for hoisting heavy materials and so on. Another promising field for this type of towing winch tractor is the hauling of military supplies of all sorts.

Except for the additional features and slight modifications necessary to adapt it for use exclusively with four-wheeled trailers, the towing tractor is built from the same specifications as the company's standard tractor, the engine, braking control, materials, special features and workmanship being the same throughout. The price of the touring tractor is $5,000 f. o. b. factory. It is made by the Knox Motor Co., Springfield, Mass.

THE COST OF MUNICIPAL WATER SOFTENING IN THE VILLAGE OF HINSDALE, ILL.*

By C. B. Williams, Consulting Engineer, 54 W. Randolph St., Chicago.

Certain cities have obtained aid from engineers in correcting a water trouble, often called the red water plague; but many towns and cities are still afflicted with what might be called the hard red water plague. This is especially true in parts of Illinois, and these cities, except for more or less internal grumbling, remain inactive.

Why any prosperous community will for years put up with a water supply which is universally condemned, is a psychological question that has never been satisfactorily answered. The same poor service from some other public utility would bring such a storm of disapproval that it would shortly be corrected.

Hinsdale, Ill., was in this rut. It is a rapidly growing suburb of Chicago of about 3,000 inhabitants. The village owns and operates a water and light plant and a garbage incinerator.

The water supplied to the village is from a 12-in. well about 210 ft. deep, the supply coming from the lime rock known as the Niagara Limestone. This water, while entirely unaffected by any surface contamination, is very disagreeable on account of its extreme hardness, its strong taste and its excessive iron content. The latter forms a deposit in the pipes, which when disturbed by an unusual consumption, as in the case of fire, or the shutting off of a district for repairs, causes the water to run red for a number of hours thereafter.

General dissatisfaction with this supply led the Hinsdale authorities to an investigation of the softening process, and to its final adoption. Last August the village put in operation a softening plant of about 1,000,000 gal. capacity, using the standard lime and soda ash process.

The old plant consisted of steam pumps, pumping directly from the well to the mains. The addition of a primary pumping unit and a softening plant made necessary the rearrangement of the steam pumps and the piping, but left them available for the final pumping.

The water is now lifted from the well by an electrically driven centrifugal pump, against a total head of 90 to 95 ft., to the top of a softening and settling tank. On entering the tank the raw water is dosed with the lime and soda ash solution. The treated water is directed downward in this tank by an interior cone to within a few feet of the bottom, thence it rises slowly allowing the precipitate to settle to the bottom. This precipitated sludge is removed daily from the tank by a revolving sludge remover and is discharged into the sewer.

The settled water is drawn off at the top of the softening tank either to a storage tank of 250,000 gal. capacity or directly to the filters. The filters are of the rapid gravity type, built over a clear well of 12,000 gal. capacity from which the steam pumps take their suction.

---

*Paper before the joint annual meeting of the Illinois Section of the American Water Works Association and the Illinois Society of Engineers.

Over the filters and clear well is a two-story brick house, the second story of which is used for chemical storage. In the lower room with the filters are the chemical mixing tanks, pumps and proportioning apparatus for feeding the chemicals.

The treated and filtered water is clear, bright and free from iron, and as operated the hardness is kept between four and five grains per gallon of hardening salts.

The following analysis of the raw, settled and filtered water was made by the State Water Survey of Illinois on Oct. 7, 1915:

PARTS PER MILLION.

	Raw.	Settled.	Filtered.
Turbidity	15	30	0
Color	5	15	0
Alkalinity	362	98	92
Sodium nitrate	1	1.6	0
Sodium chloride	2	2	2
Sodium sulphate	118	263	257
Sodium carbonate	...	47	43
Magnesium sulphate	120	...	...
Magnesium hydroxide	...	8	8
Magnesium carbonate	20	17	13
Calcium carbonate	338	16	16
Iron carbonate	3	...	...
Undetermined	42	62	31

A test of 30 days' duration has been run to determine the cost of chemicals and the amount of water used for various purposes, which gave the following results:

Total water softened	10,016,130 gal.
Total water used by consumers	8,785,208 gal.
Total water used in boilers	759,983 gal.
Total water used for washing filters	156,457 gal., 1.56%
Total water used for sludging	216,895 gal., 2.16%
Lime used per 1,000 gal	4.001 lb.
Soda ash used per 1,000 gal	1.368 lb.
Alum used per 1,000 gal	0.28 lb.

The cost of lime is 0.37 ct., soda ash 0.795 ct. and alum 2 ct. per pound; at these prices the cost for chemicals is 2.624 ct. per 1,000 gal. To this chemical cost must be added the cost for the primary pumping, which is 1.35 ct. per 1,000 gal.; the cost for attendance is small, only part of one man's time can be charged to softening, or 0.4 ct.; interest, depreciation and repairs bring the total extra cost to 5.917 ct. per 1,000 gal. This is the extra charge the village must meet to obtain soft water.

To show concretely the actual saving to the consumers for this extra expense is rather difficult. In Hinsdale the great majority of the 800 consumers have rainwater cisterns, and the houses are double piped and provided with electric or water motors for elevating the soft water. This costs each householder an investment of $300 to $500.

During this year there has been built at least 30 houses in which this investment has been saved. The interest, depreciation and repairs on the $300 minimum investment amounts to $28 per year, and is entirely saved in the new houses; while on the older houses there is at least a yearly saving of $7.

The use of bottled water by many who dislike the old water has been nearly discontinued; several laundries make large savings of soap, and boiler users save considerable sums formerly spent for boiler compounds and repairs.

It is evident that could all the various economies be as definitely shown as the cost of softening, there would be an appreciable credit to the softening process. Further, there is a certain satisfaction and value in having available any quantity of soft, drinkable and perfectly clear water, not measurable in dollars and cents.

MERITS AND DEMERITS OF THE CONTRACT SYSTEM FOR ROAD WORK.*

By R. W. Acton, Division Engineer, Minnesota State Highway Commission.

The contract system on road work, as any other system, has its disadvantages. On the small job it is the unreliable, inefficient and inexperienced jobber who must make contracting a side line rather than a business, who has primarily placed contract work in disrepute, while on the large job it has been the contract broker who has contributed to the same result. While not attempting to defend these conditions the objections are more apparent than real from a strict economic point of view.

The letting of a contract to unreliable contractors is not a fault in the contract system, but a strict error of judgment on the part of the supervising board. Lack of efficiency and experience with the small contractor is a matter for correction by education. This possibly may involve a high cost in supervision, but it is a foregone conclusion that the small, scattering jobs are a condition that must be met for several years to come and with patient effort upon the part of the engineers and supervising boards these small contractors will become a valuable asset to the community.

As to the contract broker who assumes the liability of the execution of a road contract with the point in view of scalping a profit from a following of sub-contractors, we have a condition which has become a recognized custom in nearly every class of project that may be contracted. The contract broker defends himself on the basis that his profits are a legitimate expense covering his risk for assuming the liability of the completion of the contract and furnishing a bond to cover the same.

In theory this is correct, but in practice the profits extracted for assuming these risks are entirely out of proportion to the profits for the actual performance of the work. On road work this is particularly objectionable to public officials and engineers who too often must extract a finished product for which a sufficient price is being paid, but which is actually being delivered at a loss by the sub-contractor. The condition may be overcome by co-operation between the engineer and supervising boards in splitting up a large project into several subdivisions.

By making an investigation of the contracting field it is possible to bring these subdivisions to dimensions which will not be detrimental to the project and will at the same time throw the work open to the greatest possible competition from contractors who actually intend to place a working organization on the job.

There is another class of contractors which offer even more objectionable features to the contracting system from the engineer's point of view, especially on large projects; i. e., the inexperienced contractor who can furnish a certified check, a surety bond, and a bid so low that it is impossible to perform the work on the bid prices.

Engineers may protest the letting of such a contract, knowing full well the later expense which must be encountered in supervision and litigation, but supervising boards will insist upon the low responsible bid and so long as a bond is furnished there seems to be no other method of determining responsibility. In road work this feature is becoming less objectionable, inasmuch as the surety bonding companies are becoming more wary.

The most frequent objection to contract work which are offered are the high cost of supervision, the desire to eliminate contractors' profit and the high cost as compared with the often apparent low cost of day labor over the contract system. This apparent low cost of day labor is too often the result of the lack of proper supervision with a consequent lowering of the standard of work which the contractor would be required to adhere to. Also insufficient auditing, which if as rigidly applied to the day labor system as to contract work would often reverse the final conclusions.

Eliminating the contractor's profit for the purpose of constructing a greater road mileage is only possible when the county can work up as efficient a working organization as the contractor.

The many advantages obtained by the contract system on road work are clearly found in the actual execution of the work rather than in theory. In theory there is no sufficient reason why the same degree of efficiency should not be obtained with a properly built up organization on a day-labor system as with the contract system. Ordinarily, however, the practical application of this theory breaks down for the reason that when competent management is employed for the building up of an efficient organization a necessary waste of energy must at once be expended to overcome political interference.

---

*Extract from a paper read at the annual meeting of the Minnesota Engineers' and Surveyors' Society.

The financial statement in reference to the pay rolls is of more primary political importance than the obtaining of the low unit costs in actual construction. There is a failure on the part of supervising boards to make the initial investment in necessary machinery and equipment to successfully perfect an efficient working organization.

There is a failure to grasp and take advantage of improved methods which experience have proven to be satisfactory. Minor mistakes or errors in organization are made a political issue, rather than extracting a profit from the experience and exerting a driving force to overcome a repetition of the same.

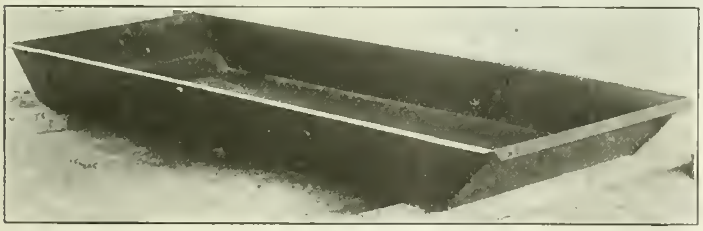
The contractor upon assuming the liability for the execution of a contract has no restrictions placed upon him except those imposed by his banker. He alone determines his equipment outlay and places at once an organization upon the work which experience has shown will obtain the most economical results. Whether in the market for equipment, material or labor, there are absolutely no restrictions imposed upon him so long as a satisfactory performance of the work is made. The contractor is directly and solely responsible for the completion of the contract for definite stipulated prices and the profits under present competition must be obtained from efficiency in organization.

Actual experience has shown that the unit prices obtained on the contract system are as low as those on day labor work under ordinary working conditions and that contract work is conducive to a higher standard of construction than is obtained under the day-labor system.

It is the writer's opinion that the educational value obtained from efficient contract work has compensated for the contractor's profits thus far.

CONCRETE AND MORTAR MIXING BOX OF STEEL.

The illustration of a steel plate mixing box for masons and concrete workers is nearly a complete description by itself. This box is 9 ft. x 3¼ ft. x 9 in. and has vertical sides and sloping ends and all corners are rounded. No rivet heads or other metal projections exist on the inside. The price is $10 f. o. b. factory. The makers are the Blaw Steel Construction Co., Pittsburgh, Pa.



Steel Plate Mixing Box for Masons and Concrete Workers.

DESIGN AND CONSTRUCTION FEATURES OF A REINFORCED CONCRETE HOTEL BUILDING AT LAKE LOUISE, ALBERTA, CANADA.

Contributed by William Wren Hay, Fort Sam Houston, Tex.,

The Canadian Pacific Railway Co. has completed extensive additions to their hotels at Banff and at Lake Louise, in the Rocky Mountains, one of the structures at Lake Louise involving unusual features of design. The group at Lake Louise provides accommodations for upwards of 400 guests, and, by reason of its isolation, has an electric light plant, water supply system, power laundry, central heating plant and septic tanks. It is connected to the main line of the railroad by about 4½ miles of narrow-gage track, on which are operated gasolene motor cars. The buildings include the main Chalet, containing bedrooms, dining room and kitchen, lounging and tea rooms; three self-contained units of 30 rooms each; a combined laundry and heating plant, all of timber construction; and a fireproof wing containing bedrooms and a large ballroom and amusement rooms, in addition to several smaller buildings and outhouses of timber.

Architectural Features.—The fireproof wing has been erected in accordance with the policy of the hotel management of replacing and adding buildings of fireproof construction throughout. The structure is of reinforced concrete construction, with solid 8-in. exterior walls and terra cotta block partitions. It is approximately 265 ft. long on its longitudinal axis, 44 ft. wide in the upper stories, and six stories high, with an eight-story tower on the front. The ground floor is devoted entirely to the public. The feature of the building is the ball room, which is about 120 ft. long, 43 ft. wide, and 20 ft. high, with six elliptical arches carrying the structure overhead. There is a total of 122 bedrooms, with 102 private baths and 8 public toilets. The exterior walls of the structure were bush-hammered and painted. The rooms are heated by steam from the central boiler plant. They are equipped with private telephones and are lighted by electricity. The whole scheme is an excellent example of design with respect to its site and the existing conditions.

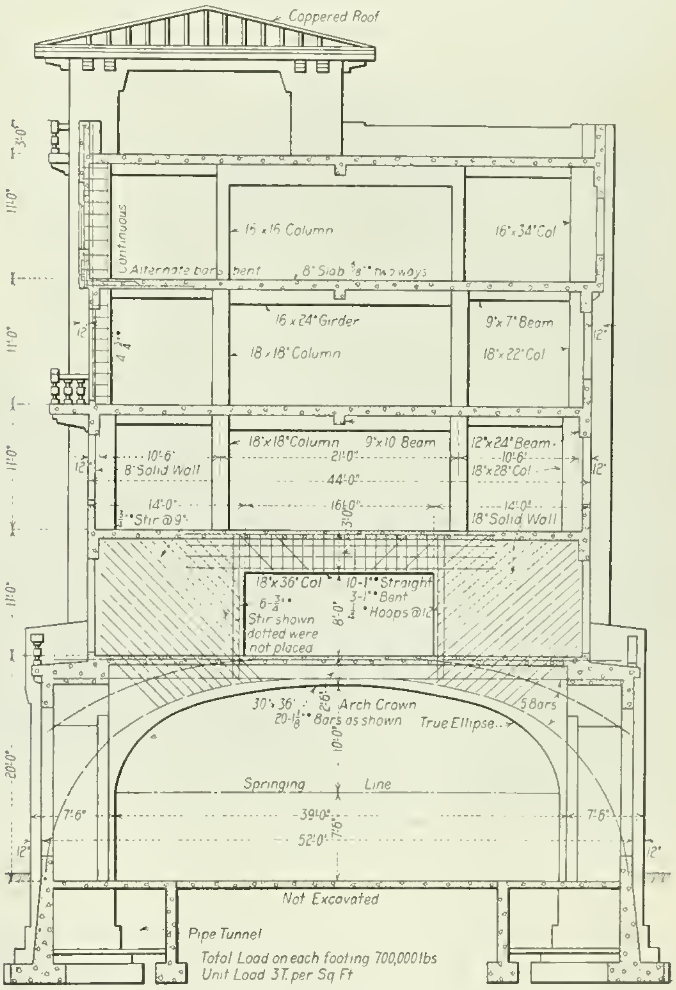


Fig. 1—Cross-Section of Reinforced Concrete Hotel Building at Lake Louise, Canada—Section Taken Through Center of Ball Room.

General Design Features.—The original buildings had been allowed to encroach upon practically all of the available ground at the outlet of the lake, so that the new wing had to be built into the side of rising ground in order to communicate with the main Chalet and at the same time face upon the lake. The principal axis of the main group was prolonged for a distance of about 75 ft., where the nature of the ground caused a change of 45° to parallel the hill. The slope of the ground was so steep that to excavate a bench for the foundations, and at the same time cut back to provide light for the rear windows, would have been extravagant. The building was therefore built upon a cut-and-fill bench.

The requirement for a large unobstructed ground floor, without excessive headroom, could be met only by the use of an arched ceiling, and the imposed weights of the four floors above rendered the design a difficult problem. It would not have been safe to have designed these arches as such, for the nature of the foundations and the absence of abutments to transfer the horizontal thrust would have invited trouble; nor was it possible to use a deep girder across the building, at least as is ordinarily done, as the headroom was limited by the architectural design and by the requirements of the hotel management.

In the design adopted (see Fig. 1) 18-in. walls, pierced to provide the corridor, were built over each arch for the full depth of the bedroom story, and the crown of the arch was designed in tension, while the beam over the corridor was designed in compression, the wall answering for the web of the girder. Except where complicated by the framing of the angles (introduced by a hexagonal tower and by the octagonal terminal at one end), and by a bend in the main axis, the beams and girders were spaced 21 ft. on centers throughout the building, enabling the use of square floor panels reinforced with steel in two directions. Over the arches the columns were spaced 10 ft. 6 in. from the main axis, and 21 ft. along the length of the building, bringing the loads from the upper stories onto the wall girder below at such a distance from the center of the span as cleared the opening through the web of the girder and simplified the design of the compression member. Generally, the beams were run around the building, and a single beam was run down the center of the three top slabs, but this center beam was omitted where the load would have come upon the center of the span, and the slab was carried from girder to girder, making the load uniform, rather than concentrated.

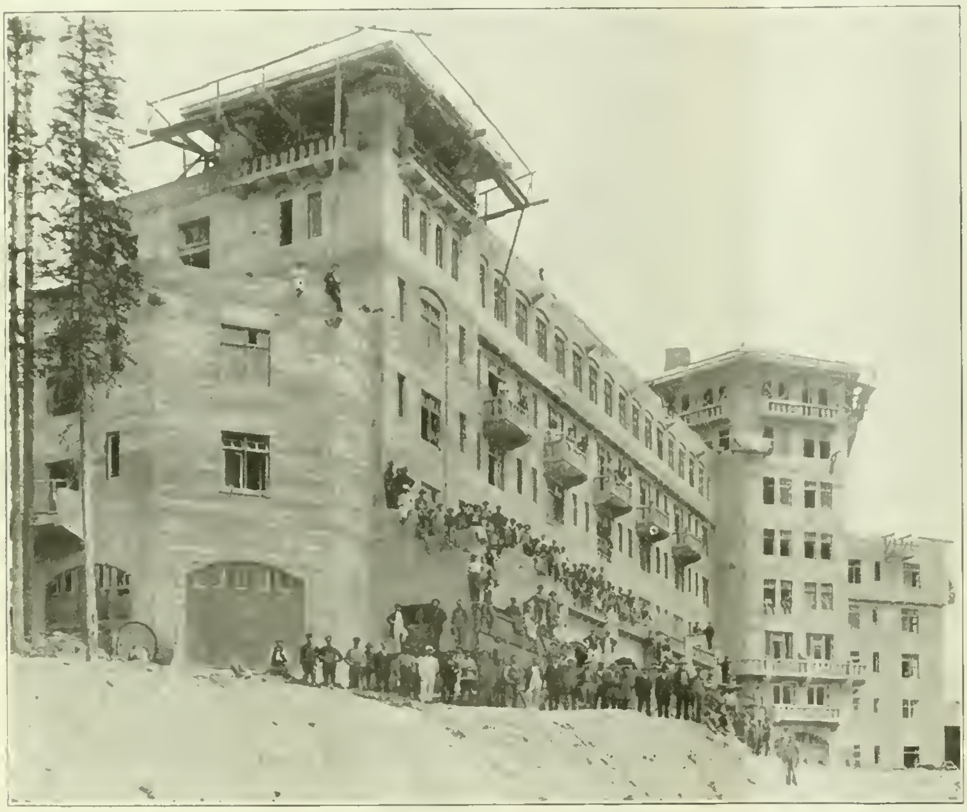


Fig. 2—Construction View of Reinforced Concrete Hotel Building at Lake Louise, Canada—Note Contrast Afforded by Finished Surface at Right.

When all the loads from the floor above had been determined, together with those from the two floors carried directly across the girder, the girder was designed for bending, as a simple beam of depth equal to the distance from floor to floor plus half the thickness of the arch crown, or 147 in. The crown, which is 36 in. wide and 30 in. thick, was then designed to carry all the tension due to bending moment plus the bending due to the uniform floor load, the reinforcing bars being so placed as to resist any such action that might be developed in the ring. The remainder of the steel was run horizontally to the outside of the building to provide for bond and to assist in taking shear. The upper chord, which is 36 in. deep and 18 in. wide, was designed as a horizontal column subject to direct compression, and also for bending due to the floor loads. Steel was placed as for a hooped column, and additional steel was added for the bending stress, the bars being bent up into the slab to take care of diagonal shear. The diagonal shear in the entire girder was estimated, taking into account the direct loads of the columns and the weight of the girder; and sufficient steel was ordered to take care of the total theoretical shear across a plane at an angle of 45° downward and to the outside from the opening through the web. As actually constructed, none of this steel was placed beyond the bottom of the opening, largely for reasons of a practical nature. The arches were poured some time before the wall above was poured, and only such diagonal steel as actually entered the arch ring was placed.

As mentioned before, there is an eight-story tower on the front of the structure, placed in the re-entrant angle formed by the bend in the axis. The tower is hexagonal in shape, with a circumscribed diameter of 56 ft., center to center of columns, and a single column in the center of the polygon. On the ground floor there is a single room, 11 ft. high, with a flat-slab ceiling, while on the bedroom floors the tower is cut up into small rooms, and beams radiate from the center, forming, with the perimeter beams, triangular slabs which were reinforced in three directions. The roof of this tower has a rise of 14 ft., the beams radiating from the central column to form the hips. In the peak, formed under this roof, there is placed a 6,000-gal. water regulating tank, of concrete. This tank is carried on similar beams placed in a horizontal plane, with a false ceiling. It is interesting to note that the rise of this roof was determined by the architectural requirement that the slope of the roof must be visible from the grounds at the edge of the lake, 200 ft. lower and less than 500 ft. away. The building terminates in an octagonal tower, 43 ft. in diameter, forming a single room on the ground floor 18 ft. high, with a single column in the center.

Except for the use of solid exterior walls, the only other unusual feature was an overhang of 12 in. in the top floor—purely an architectural feature. The extremes of temperature are very high in the Rocky Mountains, and the use of the thin walls of solid concrete might be questioned. However, ample protection against temperature stresses has been secured by reinforcing all exposed surfaces with ½-in. square twisted bars, spaced 2 ft. apart horizontally and vertically, and staggered inside and outside the walls. No difficulty has been experienced with cracking, although the total range in temperature has been known to reach 140° F.

Loads, Allowable Stresses and Assumptions.—In designing the structure the following values were used: Ratio of moduli, 15; concrete in bending, extreme fiber stress, 700 lb. per square inch; steel in tension, 16,000 lb. per square inch; concrete in compression, 500 lb. per square inch.

The live loads assumed were 60 lb. per square foot for the bedroom floors and 125 lb. per square foot for the roof. There is a 3-ft. parapet surrounding the roof, and the assumption was made that there might be as much as 2 ft. of water behind this parapet, as the snowfall in this region is normally 10 to 14 ft. per year; the equivalent of 24 ft. of snow therefore does not seem so excessive.

In general, the columns are of the hooped type, with 1½ to 2 per cent of longitudinal steel; those in the ground floor have spiral reinforcement in addition. All beams were figured for diagonal shear, and vertical stirrups were added to the bent bars, as the design and other conditions warranted. The transverse beams across the middle of the building were considered as partially continuous, and the longitudinal beams down the center of the structure, with the exception of the end spans, were figured as continuous.

Construction Features.—The progress of the work was rendered extremely difficult by the isolation of the structure, and by the condition that the heaviest work had to be carried on during winter weather. The hotel was in use from the commencement of mild weather in the spring until the late fall, and construction was not allowed to proceed during this time. In addition, materials had to be freighted up from the railroad by teams, as the connecting narrow-gage railway was not in operation at the time. It was particularly difficult to secure a sufficient supply of gravel to enable continuous progress, as the only available deposits were subject to freezing during the winter.

Construction was not ordered until the first of September, and by the middle of the month the entire structural design had been worked out in such detail as to enable the placing of the order for reinforcing steel for the first two stories. The foundations were concreted in October, and the concreting of the arches was completed in December. All floor slabs were poured solid, with a 1-in. finish. The entire area of the building was enclosed by a canvas roof, and salamanders were kept going during severe weather; no trouble was experienced due to frozen concrete.

The shape of the structure is such that it was economical to erect the forms for only one-half of the length before beginning to concrete, the remainder of the forms being erected in the open while concreting was in progress under the roof. In this way it was possible to concrete a story in two weeks, using only two complete sets of forms.

Figure 2 is a view of the building taken during its construction. It will be noted that a portion of the exterior has been surfaced, by bush-hammering and painting.

Personnel.—The writer was designing engineer at Lake Louise for the architect, Walter S. Painter, of Banff, Alberta, formerly architect for the Canadian Pacific Ry. Construction was carried out, on force account, by the company's forces, under the direction of the architect.

ESSENCE OF LAWS GOVERNING STREAM POLLUTION IN THE UNITED STATES*

By Le Roy K. Sherman, Engineer Member, Rivers and Lakes Commission of Illinois.

In Illinois and in all states where the common law is in force, it is provided that every riparian owner on a stream is entitled to a certain use of the water passing his premises in its natural unpolluted state. The riparian owner can recover damages in a suit of equity against any parties causing him injury by polluting the stream. A municipality has no greater rights to contaminate a stream than has any individual. (Village of Dwight v. Hayes, 150 Ill., 273; Robb v. Village of La Grange, 1895, 158 Ill., 21; Barrett v. Cemetery Association, 159 Ill., 385.)

In addition many states have enacted special laws governing stream pollution.

Contamination of Water Supply.—Almost all of the states have statutes providing penalties for throwing refuse or otherwise contaminating streams and lakes used as a source of water supply, or to pollute or poison streams so as to destroy fish life.

Manufacturing Wastes.—The discharge into streams of coal tar gas house wastes and oily substances is specifically prohibited in North Dakota, South Dakota, Oklahoma, California, Colorado, Wyoming and Ohio. Sawdust deposit is forbidden in Wisconsin, Missouri, Nevada and Wyoming.[1]

Pollution of Certain Specifically Named Streams is forbidden in Maine, Michigan, Maryland, New York and New Hampshire.

Use of Streams for Sewage Disposal.—Mississippi permits sewers to discharge into any navigable stream.

Virginia exempts drainage areas over 50 square miles in extent above waterworks intakes from stream pollution laws.

Massachusetts exempts the Merrimac, Connecticut and parts of the Concord River from laws governing pollution of water supply. Wisconsin laws exempt the Kickapoo, parts of the Wisconsin River and some other streams from the law against depositing sawdust and paper mill wastes. North Dakota does not prevent incorporated cities running their sewers into any river, provided that where a dam exists in the corporate limits the sewers shall discharge below the dam. South Dakota exempts mine pumpage and domestic sewage. Pennsylvania, by statute and court decree, allows waste water from coal mines, also permits discharge of sewers built previous to date of pollution law, but this application does not apply to extensions or new sewer systems.

In Indiana and New York the State Board of Health can grant permits for a limited time at discretion to manufacturing establishments to discharge wastes. The statutes specifically state, however, that this act does not prevent recovery of damages under common law proceedings.

State Regulation of Stream Pollution by Board of Health or Special Commission.

In the more densely populated states the pronounced nuisance and danger to health from stream pollution has brought about legislation for stringent regulations governing sewage disposal. The requirements are not always limited to protection of public water supply, and the board of health, or a commission, is assigned the duty of enforcing the law.

Wisconsin.—It is the duty of the State Board of Health to investigate complaints of water contamination detrimental to public health. Public hearings on complaints are held and the findings reported to the governor, and if approved by him orders are passed compelling the construction of a sewage treating plant by the offending party. An appeal from the order may be taken and the matter may be referred to two sanitary engineers who may, if necessary, select a third. The order is then enforceable by the State Circuit Court.

Massachusetts.—State Board of Health has general supervision over all stream pollution. It may make rules and regulations to prevent pollution and to protect the water supply. It must publish such orders and regulations and report annually to the general court of its doings together with any recommendations for legislation. Provision is made for appeal from the board's orders, but the order is in effect pending the appeal. Supreme Judicial Court or Superior Court has jurisdiction in equity to enforce the orders of the board.

Minnesota.—The State Board of Health has jurisdiction of pollution affecting water supply. It may order the pollution of a water supply stopped after a hearing called upon complaint of a municipal officer or ten legal voters of the town wherein the water supply is affected. Ten days' notice of the hearing is required.

New Hampshire.—Board of Health may make regulations to protect water supply. Requires publication of regulations and orders. A fine of $25 is provided for each violation.

New Jersey.—The law of 1889 provides for the creation of a State Sewerage Commission of five members appointed by the governor to investigate sewage disposal and to advise as to the best methods of treatment. It is unlawful to sewer into any stream except under conditions approved by the Sewerage Commission, with the exception that it does not apply to sewer outfalls existing prior to the enactment of the law. Annual reports must be filed (on blanks supplied) by municipalities relative to sewers and disposal plants. The law provides for the organization of sewerage districts on petition of two or more municipalities. These districts operate in a manner similar to the Sanitary District of Chicago or the Metropolitan Sewerage District of Massachusetts.

---

*From Bulletin No. 16, Rivers and Lakes Commission of Illinois.

[1] In the case of Elgin vs. Elgin Hydraulic Co., 85 Ill. App. 182 (1889) the court held that the right of the public to take water for domestic, sanitary and fire purposes is paramount to the rights of water power owners for power purposes. (Public Control of Illinois Water Supplies, J. A. Fairlie, Illinois Water Supply Association, 1914.)

The Passaic Valley District was formed in 1903 under this New Jersey law. The law creating this district was later declared by the State Supreme Court to be unconstitutional in unlawfully delegating the power of taxation to the Sewerage Commission. There were 144 sewage treating plants in New Jersey in 1913.

New York.—State Board of Health has jurisdiction of stream pollution affecting water supply. It may make orders regarding sewage treatment and plans for such works must be approved by the board. No action by any municipality against pollution of the water supply can be brought in court until the State Board of Health has determined whether the sewage does contaminate the stream. The law of 1903 provides that no sewage may be discharged into any stream without permission from the State Commission of Health. Exception is made to sewers from municipalities, etc., operating prior to date of the law, but no increase in unapproved sewage flow is allowed and permit is required for sewers extended or reconstructed. Permits to discharge sewage or factory waste may be granted by the State Commission of Health under stipulated conditions, permits to be recorded in the county clerk's office and copy sent to local board of health. If the effluent is not detrimental to health, permit shall be issued, such permits to be for a period not over two years and revocable or subject to modification after hearing. (The Indiana and Pennsylvania law relative to permits is similar to this). Local authorities are required to report annually to the State Board on blanks furnished. Violations of stream pollution laws are to be heard by the State Commissioner of Health and action shall be brought in court by the board of health for the penalty prescribed by law. The statute provides that nothing therein shall modify the common law rights of riparian owners. The following is an example of the attitude of the New York State Board of Health.

> The policy is that hereafter no person, corporation nor municipality will be permitted to discharge sewage (from a new outlet) into the Oswego River, its main tributaries nor the lakes in the drainage area unless it has been given a "preliminary treatment." The treatment required will vary with local conditions and may change from time to time, but in general it will fall into two classes: (1) Where the sewage is to go into lakes not used as public water supplies it must be so treated as to remove "all solid and suspended matter" and to prevent "odors or other offense" in the vicinity of the points of discharge. (2) Sewage going into the Oswego River, into such of its main branches as are outlets to lakes, and into lakes used for public water supply, must previously be subjected to a "complete process of purification," which shall give an effluent always free from suspended matter, and also free from "any dissolved or other organic matter that may undergo subsequent putrefaction." (Engineering News, Nov. 7, 1907.)

Vermont.—State Board of Health has general supervision of pollution affecting water supply. The statute is similar to the New York law in many respects.

Pennsylvania.—A permit is required from the Commissioner of Health with a statement of approval as to source of supply for all water supply installations. No crude sewage or wastes permitted to enter streams, except coal mine pumpage and sewage from systems existing prior to date of the act, without a permit. The following is from the report of the commission of health, Part 2, 1909, page 941:

> The law further provides that upon the application duly made to the commissioner of health by public authorities having by law charge of a sewer system of any municipality, the governor, attorney-general and the commissioner of health shall consider the case and whenever it is their unanimous opinion that the general interests of the public health would be subserved thereby, the commissioner of health may issue a permit for the discharge of sewage from such public sewer system into any of the waters of the state and may stipulate in the permit the conditions on which such discharge may be permitted. The permit before being operative must be recorded in the office of the recorder of deeds for the county wherein the outlet for the sewer system is located.
>
> As understood, the policy inaugurated is to bring about the abandonment of streams as carriers of sewage. All sewage must finally cease to be discharged, untreated, into any waters used subsequently for drinking purposes. . . .
>
> Temporary permission to discharge sewage untreated into a stream has been granted in 56 cases. . . .
>
> Twenty sewage treatment works have been designed and the plans therefore have been approved by the department.

Ohio.—Streams and sources of water supply are under the supervision of the State Board of Health. Whenever it is called to the attention of the board that sewage or other waste matter is being discharged into a stream, watercourse, lake or pond, and is in this way polluting the source of any public water supply, it shall notify such city, village or corporation causing such pollution of its findings and give an opportunity to be heard. After the hearing the board shall order such changes and improvements as it deems necessary and the same shall be paid for by the person, city or village causing the pollution.

When necessary the municipality may issue bonds for the improvement not to exceed 5 per cent of the total value of all property listed and assessed for taxation, and may be, in addition to the total bonded indebtedness permitted by law. The question of the issuance of these bonds shall not be required to be submitted to a vote. (From Ohio Statutes, Edition 1910.)

The feature of the Ohio law, otherwise known as the "Bense Act," is in the provision which automatically provides the financial means for municipalities to construct sewage disposal plants after an order has been entered against stream pollution. The Ohio Supreme Court on April 2, 1912, declared this act to be constitutional.

Indiana.—The Indiana law is similar in many respects to the Ohio law. Funds to provide for the construction of sewage treating plants can be raised by special assessments in proportion to benefits received.

Federal Statutes.—The Rivers and Harbors Act approved March 3, 1899, Sec. 13, states that it is unlawful to deposit any refuse except in a liquid state, into any United States' navigable waters, or to place material on the banks of such water where it shall be liable to be washed in and whereby navigation may be impeded and providing deposits of material may be permitted where navigation is not affected under conditions prescribed by the Secretary of War.

The Federal law prohibits the dumping of dredged or other material in Lake Michigan within eight miles of the shore.

Pollution of inter-state streams is within the jurisdiction of the Federal courts. In the well-known case of Missouri vs. Illinois, growing out of the discharge of diluted sewage into the Illinois and Mississippi Rivers by the Sanitary District of Chicago, the United States Supreme Court found no contamination, as alleged, to the St. Louis waterworks intake.

Mortar for Joints Exposed to Tidal Currents.—In building sea walls of coursed granite masonry laid in mortar and exposed to the action of tidal currents, where the bottom course is not more than 1 ft. above mean low water, much difficulty is often encountered in holding the mortar in the joints long enough to give it time to set, as the action of the rising and falling tides on the fresh mortar washes it out of place. It does not matter how rich a mortar is used, whether 1:1 or neat cement, it is impossible to keep the mortar in place until it hardens.

On one piece of construction under the writer's supervision, says Mr. J. L. Howard, in the Journal of the Boston Society of Civil Engineers, this difficulty was overcome by mixing plaster of Paris with the mortar, in the proportion of 1 part of plaster of Paris to 3 parts of 1:1 mortar. This mixture hardened within five minutes and no further trouble was experienced, due to the joints failing to set in place. The pointing of the joints in which this mixture had been used was entirely successful.

ENGINEERING CO-OPERATION.

By C. E. Drayer, Secretary, Committee on Engineering Co-operation.

One thing that stands out clearly in a study of the world's progress in recent years is the tendency to bring together scattered and highly specialized activities into organizations where effort is co-ordinated to the end that the product of the whole shall be of greater and improved quality with a benefit accruing to both producers and consumers. Whether the product is of the hand or of the brain, this statement holds true.

That engineers are somewhat behind other groups of men in the general movement toward co-operation is probably due to the youth of the profession. The period of selfish specialization from which we are emerging is one of normal development preceding the days of greater fruition when we begin to study the wider interests of ourselves and of mankind about us. At first the individual engineer worked in isolation, mentally if not physically; then came the desire to work with his fellows and the engineering society was born. Today there is a current, obvious to all, setting in the direction of an organization in which the collective efforts of engineers will be administered for the good of the profession and the public. Let us recite a few developments, some quite recent, illustrating this organized effort.

In the northwest there is in process of formation the Minnesota Joint Engineering Board whose avowed aim is to secure effective co-operation among engineers for the good of the profession, to correlate the work of engineering organizations for unity of action, to improve standards of practice and to bring about a clearer recognition of the engineer as a civic asset. The chairman of the organization (Mr. E. T. Street) is chairman of the Minnesota Branch of the American Institute of Electrical Engineers and the secretary (Mr. Geo. Rathjer) is past president of the Civil Engineers' Society of St. Paul. One of the present activities of the Minnesota engineers is an effort to have an engineer appointed to the Board of Regents of the state university.

While we are not informed as to the full scope of the organization of the Minnesota board, it appears to be an excellent arrangement for correlating the interests of the local, state and national engineering societies within the borders of the state. The logical correlation of the efforts of state organizations remains to be worked out, perhaps by the national societies when the one with the spirit of progress undertakes the leadership.

Engineers in other states are making organized efforts to secure the appointment of engineers on public service commissions. Engineers of Spokane, Wash., wrote the governor of Idaho asking him to consider the selection of an Idaho engineer to fill a vacancy on the State Public Service Commission. Pennsylvania engineering societies requested the governor on more than one occasion to appoint an engineer on the Public Service Commission. If the first efforts of this sort are not successful, it remains for the engineer through long and hard work to teach the public by word and deed that the engineer is an honest and efficient public servant, capable of taking administrative control. The ear of the politician is ever tuned to the voice of numbers.

Beginning in 1909, the Engineers' Society of Pennsylvania have held at Harrisburg five state conferences and exhibits to promote engineering co-operation, industrial and public welfare, safety and industrial efficiency. These conferences have been excellent means of educating the public and have been so satisfactory to all concerned that state departments have sought to take them over, presumably because they were successful undertakings. This same society was instrumental in promoting the act authorizing the appointment of an engineering commission to take evidence and report with recommendations in reference to a licensing law. The report of the committee to the governor has just been made public.

Licensing by states, or other suitable regulation of engineering practice, is demanded in many quarters by engineers as well as by the public. This subject requires broad and unselfish consideration. It is well for us to take cognizance of what the doctors, lawyers and architects have done and it is pertinent to say that each class must work out its own salvation according to the elements of the problem of which it alone is best able to judge. Two reasons come to mind why action should be prompt. On the one hand, due to the organized activities of architects, laws have been passed in some states which make the engineer an employe of the architect. Control is completely in the hands of architects because the state board of examiners is composed of architects. Had the engineers of Illinois, for instance, been organized to combat the pernicious legislation before it became law, they would have spared themselves humiliation and labor. On the other hand, there is a movement among engineers in at least two places to standardize wages. These conditions were theories a few years ago; today they are facts. Perhaps a recommendation by the national societies for standard practice in licensing would find favor and be generally adopted.

Within comparatively recent years there have sprung up in our larger cities local engineering societies which have met a real demand as is evidenced by their rapid growth and continued success. They furnish that companionship which must be found at home and which the national societies cannot give even by the formation of local sections of their own members. In any community there should be a local society containing all the engineers residing there. The faniced opposition of interest of local and national societies is based on a lack of comprehensive understanding and is absurd. Local sections there should be, within the local society. Strong national and strong local societies should be mutually helpful.

We must not lose sight of the fact that individual progress and growth are promoted by close acquaintance and that it is broadening to a man to attend meetings, hear papers and take part in discussions outside of his restricted specialty. It is increasing the worth of the individual until he is capable of leadership that will put the engineering profession to the front.

Particularly in the smaller political divisions like counties or cities, there is need of concerted action. The appearance before the local public of a united group of technical men capable of giving intelligent opinion on public questions would enable engineers to exert influence for good on local government. This work cannot be effectively done, if at all, from the headquarters of a natioanl society, but there should be a national organization to promote efficient management of the local society and to furnish stimulation and continuity of action.

Definite progress in co-operation between engineers themselves and between engineers and the public has been made in Buffalo, St. Paul, Philadelphia, St. Louis, Cleveland, Detroit, Pittsburgh, Nashville, Chicago, and other places. The Civil Engineers' Society of St. Paul secured the appointment of an engineer on the St. Paul Charter Commission, to whom has been assigned the chairmanship of a committee to draft provisions in the charter governing engineering activities of the city. He is also a member of the committee on civil service rules. A committee of the Buffalo Engineering Society of Buffalo advises with the newly elected City Commissioners. In Philadelphia a Development Committee has been named to formulate and solve problems arising from the recent acquisition of a large number of members. The experiences of this and other societies should be made available in concise form for the guidance of sister organizations over the country. Local societies of Pittsburgh, Detroit, Buffalo and Cleveland have visited each other during the past three years promoting an acquaintance which is of value to all. The Cleveland society plans to publish later in the year a booklet, not so much for the information of the engineer as to explain to the intelligent layman what the work of the engineer is. Other societies will be asked to co-operate in the publication and marketing of this experimental magazine.

About a year ago, almost simultaneously, two organizations were formed having a similar purpose, but differing in their methods of bringing it about. The American Association of Engineers was organized to raise the standard of ethics of the engineering profession and to promote the economic and social welfare of engineers. Emphasis is laid on the commercial phases of engineering. The Committee on Engineering Co-operation, of which Dr. F. H. Newell of the University of Illinois is Chairman, is composed of volunteer members who seek to bring about co-operation through existing organizations. When a society is found capable and willing to carry on the work of this committee, its self-imposed duties will be lightly transferred and the existence of the committee will have been justified.

An invitation has been issued by this committee to all engineering organizations to send delegates to a conference on engineering co-operation to be held Thursday and Friday, April 13 and 14, in the rooms of the Western Society of Engineers, 1735 Monadnock Block, Chicago, Ill. The following items among others may be considered:

1. Co-operation among engineering organizations. Is it desirable? In what way is it practicable?
2. Benefits of co-operation in securing greater efficiency in the larger matters of concern to the individual engineer, to the profession, and to the public.
3. Methods of co-operation now in practice in various localities; results attained in Philadelphia, St. Louis, St. Paul and other places.
4. Various kinds of engineering societies and committees and the relative efficiency of their operations.
5. Relation of the specialized or exclusive national engineering societies to their local sections or branches and to the more inclusive local engineering society or club.
6. Result of co-operation in securing wider diffusion of knowledge on engineering subjects, as illustrated at Cleveland and elsewhere.
7. The engineering profession as a whole in its present condition as regards public esteem.
8. Reasons for decline in attendance at engineering colleges. Is it indicative of healthful conditions or of proper methods of education?
9. Employment; methods and results as practiced by various engineering societies; an exchange of ideas.
10. Legislative activity, proper limits to be set, dangers to be avoided and needs of more systematic and better directed efforts.

It is desired that a representative body of engineers attend this meeting and be prepared to take part in the discussion. If it is impossible to send delegates, it is hoped that as many as possible will give the matter of procedure and organization careful thought and give the committee the benefit through written discussion.

ESSENTIAL ELEMENTS IN THE PURIFICATION OF WATER BY STORAGE.*

By Charles Gilman Hyde, Sanitary and Hydraulic Engineer.

Longevity of Pathogenic Bacteria.—It is apparent that if, under all circumstances, the length of time required for any water supply to pass from the last possible source of pollution to the point of distribution and use is greater than the longevity of pathogenic organisms under the environmental conditions which obtain, then such a supply must become safe. The result is the same as that which would be secured by other processes, as by filtration or chemical disinfection. Herein lies the fundamental principle of the purification of water supplies by storage.

The pathogenic bacteria are, as a class, used only to the rich warm juices of the animal body. If, perchance, they are cast into the relatively cold environment of a body of water they are at once confronted with conditions which are unusual and untoward. They cannot long survive.

The life of such organisms, even of the resistant minority, so-called, must be very brief. All recent experiments and investigations, conducted under modern laboratory procedure and having due regard to the conditions actually prevailing in nature, demonstrate that the great mass of typhoid bacilli introduced into an ordinary surface water supply die out in a very few days, say two or three, and that all are destroyed within, say, two weeks. A storage period of three weeks or a month would surely be sufficient to insure the destruction of all bacteria causing the group of diseases in question. Of these diseases typhoid fever is, in America, by very far the most important. In the tropics cholera is the most dreadful water-borne disease. All available evidence goes to show that the longevity of the cholera vibrio is substantially less than that of the typhoid bacillus. Bacteria causing bacillary dysentery are probably but little, if any, longer lived in water supplies than are the typhoid bacilli.

Agencies of Self Purification.—There are many inter-related agencies or factors tending to separate and destroy any pathogenic bacteria which may enter a stored water supply. Those which seem to be the principal factors may be enumerated as follows: (1) Devitalization, the general result of an unfavorable environment; (2) dilution or separation, reducing the number of organisms per unit of volume; (3) equalization or the tendency to produce uniformity in numbers and conditions; (4) sedimentation, both in the presence of particles of considerable subsiding value and without; (5) the inhibiting and destructive action of sunlight; (6) the inhibiting and devitalizing effect of relatively low temperatures; (7) low or different and always unsuitable food supply; (8) the inhibiting and destructive effect of the toxic products of saprophytic bacteria; (9) the ill-defined action of osmosis. The net result of the action and inter-action of these several factors may be summed up in the term "general unfavorable environment." In considering the efficiency of storage in the destruction of pathogenic bacteria, it is only necessary to insure that the time factor is sufficient; in other words, that the time elapsing be so great that any disease producing bacteria discharged from the human organism will be destroyed before those same germs can be re-ingested by other human beings. The expression "those same germs" is used advisedly since all the evidence at hand shows that under the environmental conditions herein considered, the pathogenic bacteria in question cannot multiply or produce their kind. The problem, therefore, becomes one of destroying certain bacteria which are extremely sensitive to environmental conditions and which cannot long survive those which are untoward.

Reservoirs as Sanitary Safeguards and Purifying Agencies.—A chain is only as strong as the weakest link determines; a reservoir, as respects the destruction of pathogenic bacteria, is only so safe as the minimum time factor represents. Most storage reservoirs are filled directly by the tributary streams from their own immediate watersheds. Very many of these are subject to "short-circuiting" by floods, which pass rapidly through them, or by waters, contributed from portions of their watersheds, which are concentrated close to their outlets. Thus, one of the most notable reservoirs employed for domestic water supply purposes in California has a capacity represented by fully 500 days of the safe yield of the catchment area, yet during maxima floods there has been wasted over its spillway in two days' time a volume of water equivalent to the entire reservoir prism.

Notwithstanding the limitations to which storage reservoirs in general are subject, the available information shows that they are in general among the greatest of sanitary safeguards for water supplies; and supplies derived therefrom are, on the average, fully as safe if not actually safer than the effluents of modern water purification plants of various accepted types. Of the 50 cities in the United States having in 1910 populations of 100,000 or over, eight have water supplies which are protected and purified by storage alone, and eleven others either have safe ground water supplies or else are sterilizing their supplies, in some cases subsequently to filtration. The average typhoid fever death rate per 100,000 for the five-year period 1909-13 for the first group of eight cities was

---

*From a report on the Sanitary Quality of the Owens River Water Supply of Los Angeles.

8.0 while that for the second group of eleven cities was 13.2.

The typhoid fever death rate in 43 cities and towns in Massachusetts whose water supplies are purified by storage alone was only 8.08 per 100,000 for the three-year period 1910-12. The average rate for the entire State during the same period was 9.5.

SUGGESTIONS FOR NEEDED DRAINAGE LEGISLATION IN ILLINOIS.*

By Joseph F. Base, Civil Engineer, Maywood, Ill.

The Illinois law (paragraph 5 of "An Act to provide for the construction, reparation and protection of drains, ditches and levees, for agricultural, sanitary and mining purposes, and to provide for the organization of drainage districts") provides that on the approval of the petition by the court, said court shall appoint "three (3) competent persons as commissioners, each of whom shall hold his office until his successor is appointed, as hereinafter provided, to lay out and construct such proposed work."

It is therefore required that each district formed shall have its individual set of commissioners who may or may not be familiar with the task before them. It is true that the law plainly states that they shall be "competent," but how often do we find the law fulfilled in this respect? I dare say that the percentage of commissioners possessing the proper initiative and working knowledge to successfully prosecute work of such importance to the public welfare is small indeed.

I contend that work carried on under the supervision of men who make drainage work a "side issue" cannot be productive of the best results. In drainage work, as in any other, there should be centralization of the executive forces and these should be composed of men who make drainage a primary instead of a secondary issue.

Too frequently, under the present methods of procedure, the commissioners have a strong personal interest in the district and there is a tendency to show partiality to either self or friends, resulting in disagreement and ill feeling and creating suspicion and revolt among the land owners throughout the district. The ultimate result is the loss of much valuable time and possibly the failure of the district.

Would it not be advisable, then, to place all drainage work within a given county under the jurisdiction of a single, disinterested, yet thoroughly competent commission? This commission might be composed of either one or three members appointed either by the County Board of Supervisors or elected by the people. This commission, devoting much of its time to drainage work, would of necessity soon become more familiar with, more efficient and better able to carry on the work than under the present method. In addition it would centralize drainage work in a manner that would make available for general use much valuable engineering data that would otherwise escape attention.

My second suggestion is that the law should be made to provide definitely for the compensation of engineers for services rendered prior to the confirmation of the assessment roll.

The law at present does not provide for the raising of funds to defray the cost of the preliminary work. The expense of the engineering work, to say nothing of time spent promoting the project, is borne entirely by the engineer with no guarantee of remuneration other than that of bringing suit if the district fails to materialize. This procedure can do no other than prove disastrous to the future good standing of the engineer in the district and surrounding territory, discourage him in promoting other projects and tend to create a sense of fear and mistrust among the land owners who might otherwise be favorable to the formation of a district.

Generally speaking, the engineer is not prepared to finance and promote the work and stand the unpleasant results of finally bringing suit to recover the money which is rightfully due him for services rendered, whether the district fails or not. It is obvious that the law in this respect tends decidedly to retard the work of reclamation instead of promoting it.

The section of the law which allows the commissioners to borrow money is effective only after the district is assured. It is my opinion that the law should provide that a small amount be assessed on all the lands within the district to defray the expense of the preliminary work. This amount need not exceed a few cents per acre, depending of course on the size and character of the district. A number of states require that the petition be accompanied by a bond to cover the cost of all the preliminary work. As far as I have been able to ascertain, no other state fails to provide either one or the other of the above means of caring for the preliminary expense.

Some will argue that the raising of moneys as suggested above would have a tendency to keep down the number of petitioners owing to this preliminary cost. In my opinion any land owner possessing enough wet land to warrant drainage would be willing to pay a few cents per acre for expert advice as to the best and most economical way of getting it, and especially if the statute so provided. In conclusion it might be well to repeat:

(1) That what we need more in drainage work in this state is centralization, not localization; fewer but better commissioners. We must have executive control which will safeguard the interests of our rural population. The rapidly increasing value of farm lands, due largely to scientific advances in agricultural methods, alone warrants this.

(2) That the profession of engineering, though bearing a high "sense of honor," should nevertheless be safeguarded to the extent that will at least insure a just return for services rendered.

THE NITROGEN FILLED INCANDESCENT LAMP FOR STREET LIGHTING.*

By A. H. Ford, Professor of Electrical Engineering, State University of Iowa, Iowa City.

During the last year the tungsten lamp has been much improved, particularly in the large sizes, which are now made in the so-called gas filled type, having a much higher efficiency than the vacuum type of lamp. This change in lamp efficiency has made possible the substitution of incandescent lamps for arc lamps with a decrease in the energy consumption. The writer, therefore, assumes that engineers will be interested in learning some of the characteristics of these lamps as applied to street lighting service.

Two kinds of service will be considered in this discussion. First, the use of lamps at street intersections only, which use in general will cover the entire street system of a city with the exception of what may be called business streets. Second, the use of lamps distributed along the curb line for the purpose of lighting the business streets.

In most Iowa cities, the amount of street traffic is such that what I would characterize as beacon lighting, with the lamps placed at the street intersections only, will be satisfactory. Such lighting has been accomplished in the smaller towns by the use of incandescent lamps of the carbon type, and in the larger towns by the use of arc lamps. Carbon lamps being very efficient may be considered as obsolete, though a few of them are still in use. Arc lamps of all types, except flaming arcs of either the carbon or metallic type, can also be considered as obsolete.

The reason that both non-flaming arc lamps and carbon incandescent lamps are continued in use is largely due to the fact that the contracts have customarily been made on the basis of using a certain type of lamp, and such contracts usually run for five or ten-year periods. One of the vital questions in regard to the introduction of the new type incandescent lamps is the question of the equivalence between the new type lamp and some old lamp which has been specified in the contract. Where the old contracts called for incandescent lamps of a certain candle power, the new type lamps have usually been introduced voluntarily by the electric power company. The introduction of the new type lamp means a saving in the energy required and therefore enables the service to be supplied at a lower cost. Where the contract called for an arc lamp, the introduction of incandescent lamps has been somewhat slower because of the lack of information as to what size of an incandescent lamp can be considered as equivalent to the existing arc lamps, thus making the electric power company hesitate in making a substitution in lamps, and thereby inviting criticism. Where 6.6 ampere alternating current enclosed arc lamps are in use, 250 candlepower gas-filled tungsten lamps can be considered as their equivalent, and where 7.5 ampere alternating current enclosed arc lamps are in use, 400 candlepower gas filled tungsten lamps can be considered as their equivalent.

---

*Abstract of paper presented at the joint convention of the Illinois Section of the American Water Works Association and the Illinois Society of Engineers, Jan. 26-27-28, 1916, at Champaign, Ill.

*From paper before Iowa Engineering Society.

The equivalence of these lamps applies not only to the total light given, but also to the distribution of the light. However, the distribution of light from either the inclosed arc lamp or the tungsten lamp surrounded by clear or opalescent globes is not the distribution which is best adapted for street lighting when lamps are placed at considerable distance from each other; that is, at the street intersections only. This distribution is much improved by equipping the lamp with a Holophane diffuser, which is an optical device acting in such a way as to turn the rays of light which would normally strike the ground near the lamp in such a direction that they strike the ground at a considerable distance from the lamp. These diffusers are normally built so that the maximum intensity of the light may be at an angle of 10 or 20° below the horizontal plane through the center of the lamp. This accomplishes two desirable results; namely, the increasing of the illumination of the street surface at a point midway between the lamps and the decreasing of the apparent brightness of the lamp; which reduces the glare effect to a considerable degree.

Where an electrolier system or curbing lighting system (as it is commonly called) is in use, the introduction of gas filled incandescent lamps reduces the energy required to a considerable amount, though if the electrical system has been laid out for operation at 110 volts this reduction will not be as great as though the system had been laid out as a constant current system operating at a current of 5.5 amperes or above. The new type of lamp has practically the same life as the old type, so if the contract with the power company calls for a lamp of a certain power consumption, the gas-filled lamp may be substituted with a result that the light is considerably increased with no additional expense.

When planning a new electrolier system, it is well to bear in mind that the present tendency is to use a single lamp per post, which is due to the fact that large lamps have greater efficiency than small lamps. The objection may be raised that it is desirable to have the top lamp of a five-lamp post lighted all night, while the lower lamps will be lighted only until midnight. Practically the same result in lighting the street can be accomplished by equipping the corner posts with slightly larger lamps and operating the corner posts all night, while the others are operated until midnight.

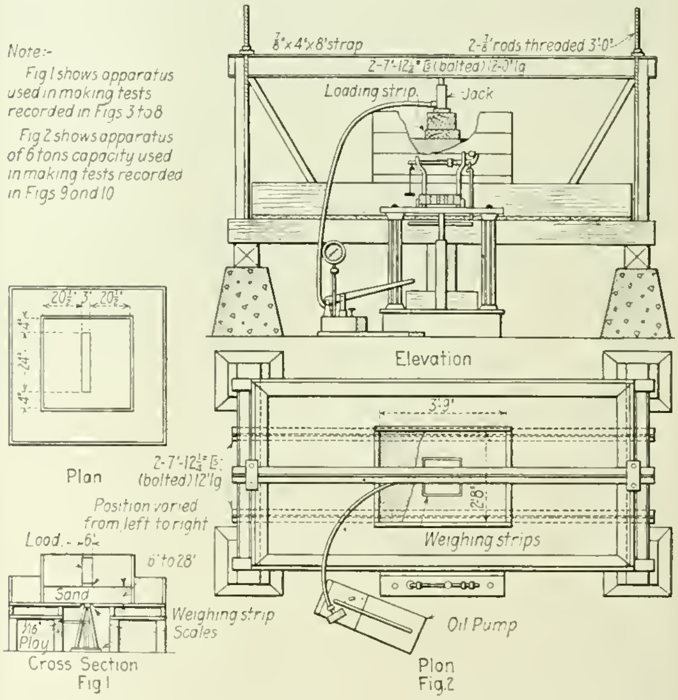
There has been a tendency to use electroliers which were too heavy to harmonize with the architecture of the buildings along the street, and this tendency has been particularly marked in the introduction of five-light electroliers. The return to single light electroliers using a rather large globe has had a desirable corrective effect in regard to the tendency to use heavy electroliers. The use of globes of a uniform size does not necessarily mean that the lamps in those globes shall be all of the same size. In fact, it is well to select lamps of such size as to compare to the importance of the street being lighted; small lamps being used in the center of the block and large lamps being used at the corners.

Incandescent lamps are used for street lighting purposes in preference to arc lamps, not only because of the technical reasons, but because there is less difference, in appearance, between large lamps and small lamps than there is between incandescent lamps and arc lamps. Therefore it is much easier, from the political standpoint, to adjust the lighting of a street to the needs of the street when incandescent lamps are used throughout than is the case when arc lamps are used for the principal streets and incandescent lamps are used for streets of secondary importance.

RESULTS OF SOME TESTS TO DETERMINE THE DISTRIBUTION OF VERTICAL PRESSURE THROUGH SAND.*

The following data describe and give the results of some experiments made at the Pennsylvania State College Engineering Experiment Station to determine the distribution of vertical pressure in earth. In the experiments reported dry sand alone was used, although it is the intention later to consider the distribution of loads through other kinds of earth as well.

Properties of Sand.—The sand used in these experiments was clean, dry river sand of a brown color such as is used for building purposes. Under the microscope it appeared to consist mostly of silica, many grains of which were coated slightly with limonite. The sand was medium as regards sharpness of grains. A sieve analysis of the sand gave the following results:


Note:-
Fig 1 shows apparatus used in making tests recorded in Figs 3 to 8
Fig 2 shows apparatus of 6 tons capacity used in making tests recorded in Figs 9 and 10
7/8"x4'x8' strap
2-7/8" rods threaded 3'-0"
2-7"-12 1/4" [s (bolted) 12'-0" lg
Loading strip
Jack
Elevation
20 1/2"
3"
20 1/2"
4"
24"
4"
Plan
2-7"-12 1/4" [s (bolted) 12' lg
Position varied from left to right
Load
6"
6" to 28"
Sand
1/16" Play
Weighing strip
Scales
Cross Section
Fig 1
3'-9"
2'-8"
Weighing strips
Oil Pump
Plan
Fig. 2

Figs. 1 and 2—Two Types of Apparatus Used in Making Tests of Distribution of Vertical Pressure Through Sand.

Percentage, by weight, caught on sieve No.—						Percentage passing sieve No.—
10	20	30	40	50	80	80
0.3	1.0	8.5	64.7	17.4	7.0	1.2

A chemical analysis of the sand gave results as follows:

	Per cent.
Moisture	0.11
Loss of dry matter upon ignition	1.01
Insoluble in acid	96.26
Soluble Fe_2O_3	0.86
Soluble Al_2O_3	1.59
Undetermined	0.17
Total	100.00

Upon vigorously shaking in water and then permitting settlement some reddish loam separated, but this did not exceed 1/4 per cent. Other properties of the sand are:

Weight per cu. ft., loose, 88 lb.
Weight per cu. ft., packed, 93.5 lb.
Angle of repose, 33° 20′.
Percentage of voids, 36.6.

First Experiments.

The apparatus first used consisted of a box about 8 ft. square and 1½ ft. deep, raised about 3 ft. off the floor. A hole 24x36 in. was cut in the center of the bottom, and in it were placed six 6x24-in. slats supported at one end on a piece of 1-in. pipe. At the other end each slat was supported by a 1 to 1 lever mounted on a 1-in. pipe, bearing and working on the slat in the same manner. The weight on the slat was measured by a spring balance connected to the outer end of the lever, which was supported so as to hold the slat in a horizontal position level with the other slats and the bottom of the box.

---

*Abstracted from Bulletin No. 8 of the Pennsylvania State College, by R. B. Fehr and C. R. Thomas.

At first short pieces of rope were used to take up the extension in the balances when weighing. The stretch in the ropes made this impracticable, and they were soon replaced by small threaded eye bolts run down through a steel angle. A piece of cloth was spread lightly over the slats to prevent the sand which was to be piled on top of them from running through. The sand was struck off to a certain depth and the weight on each slat was obtained by pulling down on the spring balance until the pressure against the supporting strip was relieved. Readings were then taken on the balances. A load of brick was placed on a loading slat 6x24x¾ in. over one of the movable slats and the spring balances pulled down. Readings were again taken on the balances. The difference between two consecutive readings on the same balance multiplied by 2 gave the effect of the external load on that slat.

The results of tests with this apparatus showed in a general way that the pressure due to a concentrated load on the sand was distributed over a large area. The tests showed that this kind of apparatus could not be relied upon to give consistent results, for in some cases the pressure transmitted on the slat directly beneath the load was less than that on other slats. Such results are contrary to both theory and practical experience, and this apparatus was therefore considerably modified.

Improved Form of Apparatus.

The 6 slats of the original apparatus were replaced by 14 slats, each 24x2½ in., supported on knife edges. A steel straight edge was placed under the movable end of the slats in order to support them until the spring balances were pulled up enough to make the slats clear this straight edge by a definite amount (.005 in.), as measured by a thickness gage. Surrounding these slats and resting on the floor of the larger box was a bottomless box, 3x4 ft. x 4 ft. deep. This arrangement afforded constant conditions of restriction for the sand under test. The other arrangements were the same as in the preceding apparatus.

After spreading a piece of cloth over the slats, dry sand was shoveled into the smaller box, thoroughly packed, and leveled off. The spring balances were all pulled up so that the slats cleared the straight edge by .005 in. and the readings recorded. A definite loading of brick was applied on a 6x24-in. board, ¾ in. thick, resting on top of the sand directly above the two middle slats, and the operation for taking readings repeated as before. The difference of the scale readings before and after the external load was applied gave the amount of pressure transmitted through the sand.

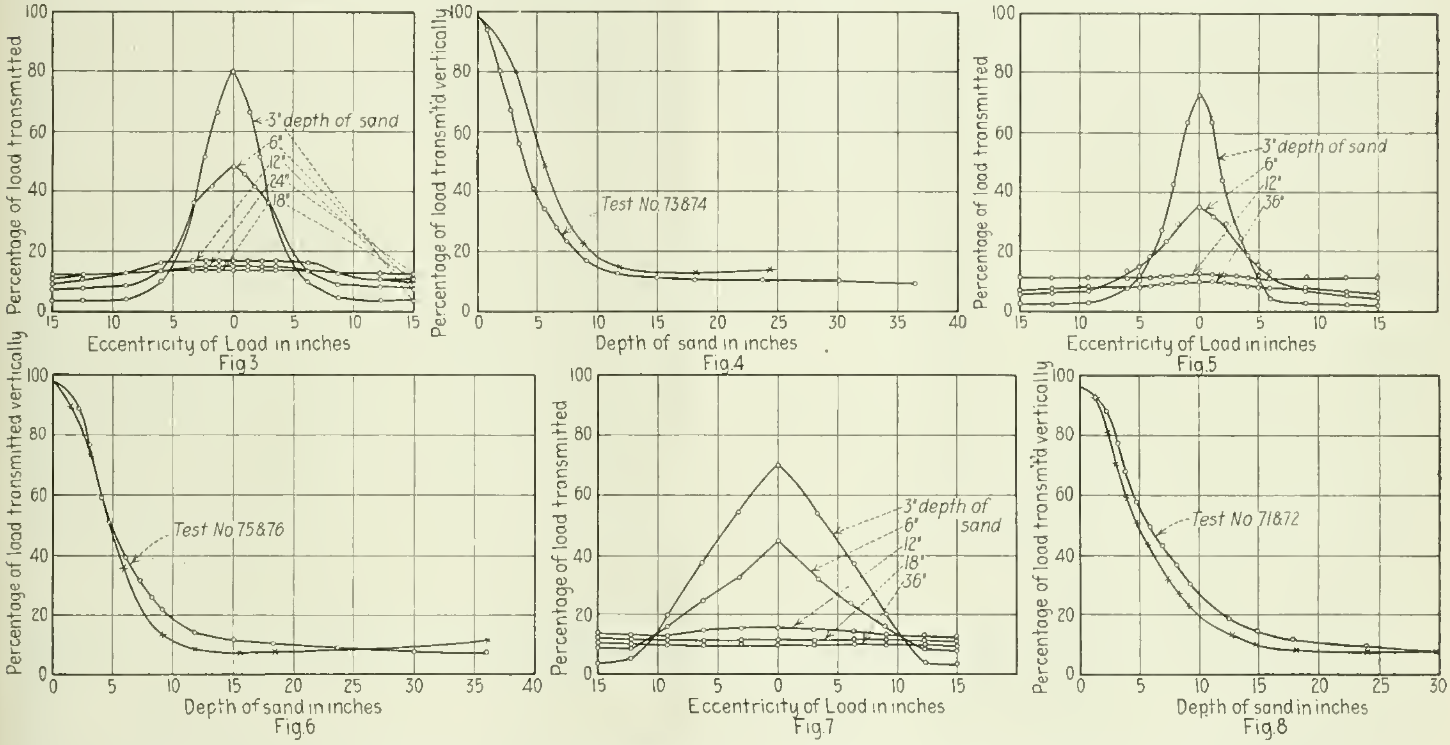
A sufficient number of tests were made with this apparatus to prove that it was not satisfactory. The results were not much better than those obtained by the crude original apparatus, for they fluctuated greatly and apparently bore no relation to each other. The cause of these inconsistencies was probably due to the fact that the movements of the slats caused by adjusting the spring balances to the point where the slats cleared the straight edge by a definite amount were too great, thereby causing a movement of the sand grains and consequently a redistribution of the pressure.

It was therefore evident that, in order to obtain reasonably accurate results, the movement of the weighing strip must be made much smaller. Accordingly a platform scale was used in place of the slats, levers, and spring balances.

Apparatus With Platform Scales As Weighing Device.

The slats were removed, and the 24x36-in. opening in the sand box was boarded up leaving an opening as shown in Fig. 1. In this opening there was placed the weighing strip supported wholly and directly by the platform of a small 30-lb. platform scale. The scale ratio was 50:1, and as the movement of the arm was restricted to 1/16 in. the maximum movement of the platform and therefore of the weighing strip was $\frac{1}{50} \times \frac{1}{16} = \frac{1}{800}$ in.

Since there was but one weighing strip, the distribution of pressure had to be obtained by varying the position



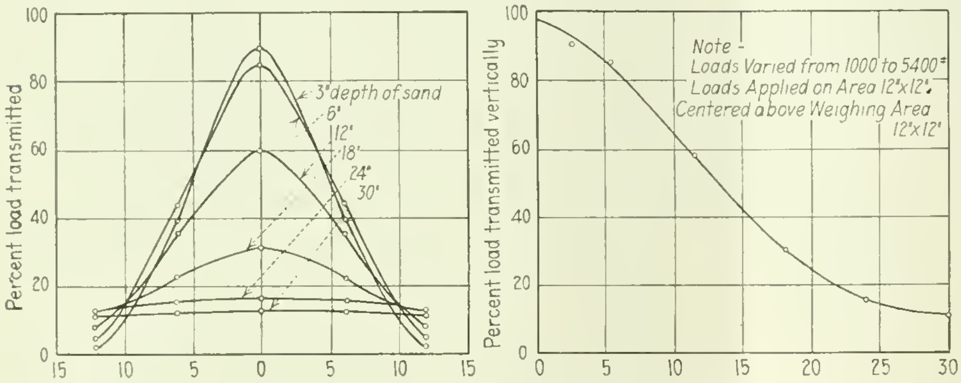
FIGS. 3 TO 8—RESULTS OF TESTS SHOWING PERCENTAGES OF LOADS TRANSMITTED THROUGH SAND WITH LOADS VARYING FROM 60 TO 300 LB., CENTRALLY AND ECCENTRICALLY PLACED, USING APPARATUS SHOWN IN FIG. 1.

Fig. 3—Percentages of Load Transmitted at Various Distances from Center and for Different Depths; Loading and Weighing Areas 6x24 In. Fig. 4—Percentages of Load Transmitted Vertically Through Various Depths; Loading and Weighing Areas 6x24 In. Fig. 5—Percentages of Load Transmitted at Various Distances from Center and for Different Depths; Loading and Weighing Areas 6x6 In. Fig. 6—Percentages of Load Transmitted Vertically Through Various Depths; Loading and Weighing Areas 6x6 In. Fig. 7—Percentages of Load Transmitted at Various Distances from Center and for Different Depths; Loading and Weighing Areas 12x12 In. Fig. 8—Percentages of Load Transmitted Vertically Through Various Depths; Loading and Weighing Areas 12x12 In.

of the load. A scale reading was observed: (1) with no load on top of the sand, and (2) after a definite load had been applied on a loading strip equal in area to that of the weighing strip. The difference between the two readings gave the amount of pressure transmitted through the sand. This difference divided by the known weight of the load multiplied by 100 gave the percentage of the load transmitted vertically through the sand.

Description and Results of Tests.—Every test made with this apparatus gave results which appeared to be consistent and which could be duplicated in subsequent tests. The small fluctuations that occurred were such as might reasonably be expected in such work. In fact the success of this simple platform scale apparatus seemed so assured that it was decided to build a larger apparatus having a capacity of six tons. Meanwhile a rather extensive series of tests was run to determine, as far as possible, the variation of pressure for small loads.

In these tests the loads varied from 60 to 300 lb. and consisted of bricks piled upon the loading strip as before explained. The position of the load was varied from the center directly over the weighing strip to a position where the eccentricity (the distance from the center) was 15 in. By moving to the right and then to the left a double set of observations was obtained.



FIGS. 9 AND 10—RESULTS OF TESTS SHOWING PERCENTAGES OF LOADS TRANSMITTED THROUGH SAND WITH LOADS VARYING FROM 1,000 TO 5,400 LB., CENTRALLY AND ECCENTRICALLY PLACED, USING APPARATUS SHOWN IN FIG. 2.

Fig. 9—Percentages of Load Transmitted at Various Distances from Center and for Different Depths; Loading and Weighing Areas, 12x12 In. Fig. 10—Percentages of Load Transmitted Vertically Through Various Depths; Loading and Weighing Areas 12x12 In.

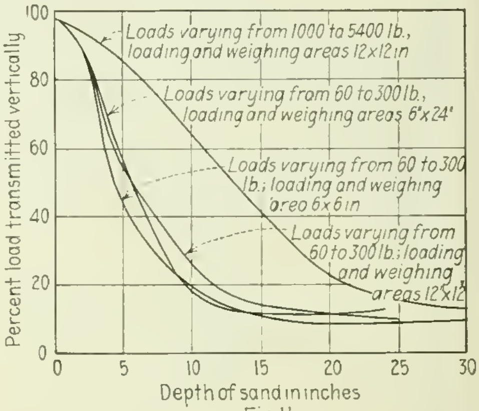


Fig. 11—Curves Showing Percentages of Load Transmitted Vertically Through Various Depths of Sand for Different Tests.

Tabular data (omitted in our abstract) give the results of tests made with a 6x24-in. weighing strip and a loading strip of equal size; for a 6x6-in. weighing and loading strip; and for a 12x12-in. weighing and loading strip. The last two tests in each case were made with varying depths of sand, there being no eccentricity of loading; these were made for the express purpose of checking up the results obtained for zero eccentricity in the preceding tests.

In checking the results it was noted that the calculated percentages of transmission for each group of five observations lie for the most part well within 10 per cent of the mean value. Furthermore, there are just as many of the results for the 60 and 300-lb. loads below the average as there are above. Hence these averages may be regarded as representative values of transmission percentages for all loads of from 60 to 300 lb. per square foot for loading and weighing strips 6x24 in. and 12x12 in., and for loads 240 to 1,200 lb. per square foot for the 6x6-in. strips.

The curves in Figs. 3, 5, 7 show how the vertical component of pressure due to a concentrated load is distributed. The points plotted were the averages of all the results obtained for a given depth of sand and a given eccentricity of load, either right or left. A study of these curves reveals the fact that there is a sudden bend in all of those for depths of sand less than 12 in. at the point where the eccentricity is equal to the width of the loading strip. In other words, this sharp bend always seemed to occur when the loading strip was no longer over any part of the weighing strip. Beyond this part of the curve the per cent transmission was always less than sixteen.

The curves in Figs. 4, 6, 8 show the relation between the pressure transmitted vertically and the depth of sand, when the load was applied directly over the weighing strip. The points marked with a cross were obtained from the distribution curves, while the points marked with a circle are the results of the last two tests in each table. As previously stated these two tests were made for the purpose of checking up the results of the other tests for zero eccentricity. The agreement of the two curves appears to be as good as can reasonably be expected in such work. It is to be noted that for depths of sand over 12 in. the per cent transmission was always less than twenty.

Tests With Large Apparatus.

The large apparatus shown in Fig. 2 was designed and constructed for the purpose of applying loads up to six tons. The principle is the same as in the first platform scale apparatus, the main difference being in the application of the load by means of a calibrated hydraulic jack instead of by applying a known load of bricks. Referring to Fig. 2 the sand box is supported on concrete piers between which is placed the platform scale. A wooden column 6x10 in. in size and about 3 ft. long supports the weighing strip, 12x12x2 in., which is at the level of the floor of the sand box. The loads are applied to the surface of the sand on a 12x12x2-in. loading strip. The jack is blocked up so that it works against the overhead I-beam. The end tension rods are threaded to permit an easy adjsutment of the height of the I-beam above the surface of the sand. The interior box containing the sand under test was of the same size as that used in the former tests.

The platform scale was a Standard having a weighing capacity of 4,000 lb. and a scale ratio of 200 to 1. Since the motion of the beam was restricted to $\frac{1}{8}$ in. the maximum movement of the platform, and therefore of the weighing strip, was only $\frac{1}{8} \times \frac{1}{200} = \frac{1}{1600}$ in.

The hydraulic jack had a capacity of 20 tons and was supplied by the Elmes Engineering Works, of Chicago. As it was only 10 in. in height and 4 in. in diameter and had an independent pump, it made a very convenient means of applying a known load.

The calibration of the jack was accomplished by placing it between the compression heads of a 100,000-lb. Riehle testing machine and applying the load in exactly the same manner as it was applied in the sand pressure test. This application of load was made by pumping up the jack until the hydraulic gage registered the desired pressure. To maintain this pressure constant it was necessary to push down on the pump handle very slowly because of the slight leakage in the system. In case the pressure rose above that desired the by-pass valve was opened and the jack again pumped up. It was found necessary to follow this method of procedure in order to secure uniform results. After holding the jack at this pressure for about

15 seconds the reading of the scale beam was noted and recorded. This operation was repeated four times from 0 to 20,000 lb., always on increasing pressure. Another set of similar observations was taken on a different day and the average of results of both observations made a very smooth calibration curve. The averages of these two sets of observations lay well within 2 per cent of the mean and for the purpose of these tests this accuracy was quite sufficient.

Method of Conducting Tests.—In conducting these tests a uniform method of procedure was adopted as before. The sand was packed and leveled off and the loading strip embedded as firmly as possible by hand pressure 12 in. to the right of the center of the weighing strip. The blocking and jack were placed in position and a dead load reading of the scale was taken. Loads were then applied and readings taken of the scale beam for various loads up to the capacity of the scale. It was found necessary to watch the jack and loading strip carefully during the application of the loads, for the jack showed a tendency to get out of plumb and the loading strip to sink unevenly in the sand. In such cases the test was discontinued and run over again.

Care was taken to maintain the load for a short time at each observation of the scale beam and readings were always taken on an ascending pressure as indicated on the hydraulic gage.

Description of Tests.—A series of tests was run under the same conditions as the tests shown in Figs. 7 and 8., in order to find out whether larger loads would make any difference in the percentage of transmission. The depth of sand was varied from 3 in. to 30 in., and the eccentricity from 12 in. on the right to 12 in. on the left. The loads were varied from about 300 lb. to a maximum of 5,400 lb. applied on a loading strip 12x12 in. Figures 9 and 10 show the results of these tests.

Discussion of Results.—In connection with these tests the following points should be noted:

(1) The loading strip (12x12 in.) began to sink in the sand at loads of approximately 2,500 lb. where the sand exceeded 12 in. in depth. For depths smaller than this the sinking did not become pronounced until a much higher load was reached.

(2) At each increment of load after sinking began additional sinking occurred. Readings, however, were not taken until the block became stationary under the applied load.

(3) A distinct heaving and flowing of the sand occurred for some distance on each side of the loading strip. The sand usually assumed a water ripple formation surrounding the block. As many as three ripples of ½ in. in height occurred.

(4) In every case the percentage of transmission appeared to show a uniform increase as greater loads were applied. It is possible that this may be due to the flowing of the sand as well as the slight decease in depth due to the embedding of the loading strip.

(5) A marked decrease in the percentage of load transmitted occurs when the eccentricity of the loading strip equals its width.

(6) This decrease became less marked as greater depths of sand were reached, as indicated by the flattening of the distribution curves (Fig 9).

Conclusions of Various Tests.

At the present time the results of the tests so far conducted appear to indicate:

(1) That at depths of 12 in. for smaller loads (up to 300 lb. per square foot) and 23 in. for larger loads (up to 5,400 lb. per square foot) the percentage of transmission appeared to have a maximum value of twenty (see Fig 11).

(2) That the point at which a marked change occurred in the percentage of transmission due to eccentricity was at a distance from the center equal to the width of the weighing strip, and at this point the maximum transmission was 16 per cent. For greater eccentricities this value was never exceeded.

SPECIAL FEATURES OF FOUR NEW WATER PURIFICATION PLANTS IN INDIANA.*

By John C. Diggs, Water Chemist, Indiana State Board of Health, Indianapolis.

Four new water purification plants were installed in Indiana during 1915. The plants are probably called upon to work under as greatly varying conditions as it is possible to conceive.

The plants are located at Logansport, Princeton, Paoli and Wolcott. The plant at Wolcott was installed with a new public water system and put in operation in the spring of 1915. The other three filtration plants were constructed to furnish a potable supply at cities where previously raw surface water had been supplied.

The Logansport plant takes its supply from Eel River, a more or less badly polluted stream which in past years has been a very large factor in causing the very high typhoid fever death rate in that city. Princeton obtains its supply from the Patoka River and the Paoli plant obtains a supply from Lick Creek. Neither of these streams is seriously polluted, but each is very objectionable on account of high turbidity following every slight rainstorm. The Wolcott supply is taken from a gravel pit fed by springs. The plant operation is practically automatic.

Logansport.—The purfication plant at Logansport was put in operation in the spring of 1915. This plant is comprised of an intake, low-duty, raw-water pumping plant, a coagulating and sedimentation basin, eight gravity filters, a filter house containing apparatus for the storage and preparation of chemicals in solution, a laboratory and a clear water storage basin located beneath the filters.

Under normal conditions the raw water will be pumped directly from the "stilling" basin, which is located in the race, through which flows the water used in the turbines, which operate the pumps furnishing the city pressure. This basin is constructed of concrete and timber and has a capacity of practically 500,000 gal. A second intake may draw water from above the dam, which is located about 600 ft. above the raw water pump house. A 36-in. cast iron pipe, controlled at both ends by sluice gates may bring the supply to the raw water pumps in case the race is closed for repairs or other cause.

A 24-in. emergency intake extends to the river in order that water may be taken direct from this water should an accident prevent the use of the filter plant.

The raw water pumping station consists of three electrically driven, Worthington centrifugal pumps, each of 4,000,000-gal. capacity per day, coagulant feeding device and float controls for automatically regulating the work of the pumps.

The sedimentation basin built of reinforced concrete is 125 ft. long and of 52 ft. average width and 12.5 ft. deep. It has a "slab" concrete roof and stilling walls located at each end. The capacity is approximately 600,000 gal. This size permits, with complete displacement, a settling period of 1.8 hours and lineal flow of 1.1 ft. per minute when the plant is working at the 8,000,000 gal. per day rate. The basin must be entirely emptied for cleaning.

The filters, each 22.5x16 ft., are arranged in two rows of four each on the opposite sides of the operating room and pipe gallery. The construction, save the strainer system and wash water removal troughs, are entirely of reinforced concrete.

The water is supplied to the filters by sheet metal troughs and passes through 28 in. of sand and 19 in. of gravel. The strainer system consists of cast iron manifolds, into which are screened 1½-in. galvanized iron pipe bored with ¼-in. holes.

The sand beds are washed by an upward flow of water forced back through the strainer system by two electrically driven Worthington centrifugal pumps, each of which will supply water so as to produce an upward flow in the filters of 18 in. per minute. The filters are manually operated and each is rated at 1,000,000 gal. per 24 hours. Rate control regulators are provided. Downdraft tubes, with water seal, are provided to increase the downward pressure.

---

*Paper before Indiana Sanitary and Water Supply Association.

The clear water well is directly under the filters and pipe gallery. Its capacity is 260,000 gal.

Sulphate of alumina is used as a coagulant. "Hypochlorite" is applied at two points: as the water leaves the sedimentation basin and as the filtered water goes into the suction line. This double chemical treatment permits the addition of a comparatively large amount of the "hypo" to the settled water, any objectionable taste or odor being removed by the filters. Treatment at this point also gives a long contact period before the water is pumped into the mains. Treatment at the suction will probably not be necessary during a large part of the year.

Two 24-in. cast iron intakes lead from the clear well to the pumping plant. This plant consists of five pumps. These are: One Allis-Chalmers cross compound condensing steam pump with a capacity of 6,000,000 gal. per 24 hours; one Fairbanks-Morse tandem, compound, condensing steam pump, with a capacity of 3,000,000 gal. per 24 hours; one Laidlaw-Dunn-Gordon water power pump, with a capacity of 3,000,000 gal., and two Holly combination steam and water pumps at 1,500,000 gal. each.

A series of bacterial tests were made on this plant in May, 1915. At that time the plant was producing a very satisfactory effluent. Later in the summer, however, owing to the high turbidity of the raw supply, the sedimentation basin was permitted to fill to a depth of 8 ft. with mud. This greatly reduced its efficiency and made necessary the use of an exceedingly high rate of chemical feed. For a continued period the plant was operated, using 9 grains of alum per gallon and 25 lbs. of "hypo" per 1,000,000 gal. For this period the daily cost of chemicals amounted to more than $80 per day for a city of 20,000. Upon cleaning the basin the cost of chemicals was reduced practically $50 per day.

Princeton.—The public water supply for the town of Princeton is taken from the Patoka River, a comparatively clean stream of water whose chief pollution is that received from the drainage of the agricultural lands on its watershed. On account of the steep slopes of its narrow valley, it is a stream which carried an unusually high turbidity during portions of the year. For this reason filtration is especially necessary for the production of a water supply satisfactory for domestic use.

The water is drawn from a suction well located on the bank of the stream and pumped by a low-lift centrifugal pump into a sedimentation basin of approximately 1,000,000-gal. capacity. This basin is baffled so as to bring about entire displacement. The lower portion of the basin is baffled to be used as a coagulating basin. This portion is 75 ft. long by 25 ft. wide by 11 ft. deep, with a capacity of 240,000 gal.

Alum is used as a coagulant. Provisions are made for the addition of lime or soda to the raw water as it goes to the sedimentation basin and as it flows into the coagulation basin.

From the coagulation basin the water flows through a raw water channel which supplies four gravity filters, only three of which are now equipped for service. Each of the filter units has a sand area of 261 sq. ft. and is rated at 750,000 gal. per day. The filtering medium consists of 30 in. of Cape May sand supported by gravel graduated in size. The strainer system comprises cast iron manifolds with 2-in. galvanized pipes as laterals into which the brass strainer heads are screened. Wash-water pressure is obtained from a 40,000-gal. standpipe located adjacent to the filter plant. Air wash is also provided. The filter basins are of rather unusual depth, being 12 ft. deep and, as a general rule, the water level in the filters is about 7 ft. above the top of the sand layer. This arrangement permits of a continuation of the filtering process for several hours if it should be necessary to stop the river pump.

The filtered water is collected in an uncovered, reinforced concrete reservoir of 1,000,000-gal. capacity. The water is pumped into a standpipe by a 2,000,000-gal. Laidlaw-Dunn-Gordon pump, which maintains a discharge pressure of 125 lb. and a city pressure of 60 lb. A "booster" pump located near the city permits a pressure of 130 lb. for use in case of fire.

A laboratory is installed to assist in keeping the plant working at high efficiency. Examinations made on samples taken from the plant indicate that the plant is producing a satisfactory removal of both bacteria and sediment.

Paoli.—In the year 1895 a private company built a public water system in Paoli which was afterward sold to the town. The source of the supply was Lick Creek, an adequate supply, but one, of course, which was exposed to surface pollution from barnyards and fields. This supply also became quite muddy, following heavy rains. The water was pumped to a reservoir located at the top of a hill, and from the reservoir it flowed by gravity to the city mains.

On account of the unsatisfactory supply obtained from Lick Creek, attempts were made to obtain an additional supply from the sources, but all resulted in failures.

In the spring of 1915 the town decided to install a pressure filter plant to be furnished by the Norwood Engineering Co. This plant, as now constructed, comprises an intake, a pumping station and filter plant, a storage reservoir and a distribution system.

The supply is obtained from Lick Creek through an intake and goes directly to the pumps which are located in the building with the filters on the bank of the creek.

Two pumps are provided, one built by the American Steam Pump Co., with a capacity of 400 gal. per minute when operating at the rate of 40 strokes per minute, the other a Dean pump of about 10,000 gal. capacity per hour. In practice the American pump is used practically all the time, the Dean being kept in repair for emergency. The filter plant consists of one 8x20-ft. steel coagulating tank, three 8-ft. pressure filters, an alum feeding device and a hypo feeding device. The alum solution is fed into the suction line from the intake. The water passes through a coagulating tank and goes to the top of the filters.

Filters of this type are designed to operate at the rate of 125,000,000 and 175,000,000 gal. per acre of sand surface. With the water as turbid as this supply becomes during periods of rains, operation at a rate faster than 125,000,000 gal. cannot be expected. When operating at the rate of 125,000,000 gal. per acre of sand surface, the three 8-ft. filters will produce 18,000 gal. of water per hour, approximately 432,000 gal. per day.

This plant is operated in conjunction with the city lighting plant. The installation of the filtration plant called for no additional expense for labor.

Wolcott.—In choosing a source for their public supply Wolcott decided upon water drawn from an abandoned sand pit as being preferable to a highly mineralized water obtainable from wells.

The system, as completed in the spring of 1915, consists of an intake and gravity feed line leading from the sand pit. This reservoir of water comprises some two acres of surface and is about 25 ft. deep. The supply is furnished by springs which feed into the bottom of the pit. The water flows by gravity through one-half mile wooden conduit from the reservoir to the pumping station.

The apparatus of this plant is comprised of an automatic, electrically driven pump, one 250,000-gal. unit pressure filter, an electrically driven air compressor and a 14,000-gal. water storage tank.

On account of the short period the system has been in operation, the number of consumers is small. The present pumpage is probably not more than 30,000 gal. per day.

Engineering and Contracting

Devoted to the Economics of Civil Engineering Design
and to Methods and Cost of Construction

EDITORS
H. P. Gillette C. S. Hill C. T. Murray S. C. Hadden C. W. Malcolm

Volume XLV. CHICAGO, ILL., APRIL 5, 1916. Number 14.

THE OPENING OF THE ROAD BUILDING SEASON.

With April, in those states where activity is greatest, begins the season of road construction. It is timely, therefore, with our first April issue to estimate the prospects of the season, and this we do in this issue. One without experience in making such a compilation as we publish has little understanding of its troublesome details and of the difficulty of even approximating useful completeness of data. With the most specific warnings to the contrary, mileages and quantities are reported without costs or costs and mileages are reported without quantities and the result is deficient in anticipated value. So in the statistics which we have compiled, if the data are fewer from a county or city than the number that would be most useful, the cause is a defective report that reasonable inquiry could not better. Withal, the representation is impressive. Summary and analysis of the figures are given in a more appropriate column.

Road building in 1915 won a cherished place in the consideration of the contractor and the engineer. It was the only line of construction engineering which maintained a normal degree of activity. In 1916 the supremacy of road building in this respect while less pronounced, will from all evidences be maintained. It will this year, as it did last year, afford a refuge for the contractor and engineer left unprovided by decreased railway and levee and municipal works construction. This fact alone warrants pronounced attention to the road construction field. But there is another reason for special consideration of road construction.

As was railway construction in 1887 and for the few years before and after that year of greatest activity, road construction is in these present years the predominating development of the period in civil engineering. In the years around 1887 contractors and engineers computed prosperity in terms of railway construction. Probably no one line of engineering construction ever again will achieve such pronounced predominance as did railway construction in its generation. The sum of all engineering work has in 30 years grown so large that no single item can easily reach a size which peaks markedly above the high average of all items. We can say, however, that no single class of engineering structures so nearly reaches this prominence as do roads. This is not so merely because the sum of expenditures for roads is large, but also because the activity in road construction and the sentiment for improved roads is country wide.

The sentiment for improved roads is uncertain of its object and of the way to that object, if the year's records are read correctly. To cite instances, it appears for the first thing, while central direction of road improvement methods is growing in recognition, means for effective direction are slow to be provided. During the last year or two, laws, generally praiseworthy in scope and power, for control of road construction have come into existence without adequate provision in appropriation acts to make effective control possible. A second drawback is lack of general conviction that road building is a task calling for trained engineering, planning and supervision, and that expenditure in preparatory engineering work is profitable. In several states where new Road Commissioners have begun work during the year the most frequent criticism had to be met was the charge that money spent for surveys and plans was wasted. In similar ways it is demonstrated on every hand that sentiment for improved roads has not systematized itself into policy and still less has policy settled down into accepted codified practice. There is no cause for discouragement because of this condition. It merely exemplifies democracy running true to form.

The great bulk of the systematically planned and competently directed road construction of this nation is confined to a moderate area of the country. The remaining area devotes great sums to road work, but the money is giving little of permanent value and only a little more of even temporary transportation convenience. Impotency is yet the distinguishing characteristic of the peoples' highway policy. Insensibility to the advantages of a better highway system is, however, no longer a characteristic of the people. In these two statements we have very nearly the summation of the improved road situation in the United States.

A NOTABLE EXAMPLE OF CONCRETE ROAD ENGINEERING.

The precisian in engineering persistently longs for the ideal engineering commission. This ideal commission is one in the performance of which he has complete freedom to utilize every resource of engineering attainment to produce perfect work. Commissions of this nature are exceedingly rare in this workaday world, but it is pleasant to dream of them and more pleasant once or twice in life to run upon an actual example. It is partly with this sentimental object in mind that we publish in this issue so detailed an account of the construction of the Coleman-DuPont concrete road in Delaware. In constructing this road there are few resources available to engineers which the engineer has not been at liberty to requisition.

It is rare that the engineer can exercise freedom in selecting road alignments and grades. In the case being considered this freedom was substantially complete. More rarely still does the engineer have freedom to study and plan roadbed drainage. A drainage survey of a roadway route, and of the extent and precision of that made for the Coleman-DuPont road, is so unusual that it begets awe. And drainage so complete that it involved emptying dry the swamps traversed goes beyond all but the imagination of most road engineers. When the climax is capped by a materials investigating laboratory at the engineer's command and a testing routine that places each week on the engineer's desk an analysis of the quality of mixing water the engineer experiences almost a hiatus of mentality. Yet all of these resources and many others have been at command in the work described elsewhere in this issue.

The Coleman-DuPont road is a full size model laboratory and field investigation of road construction materials and methods. It should furnish, when the records are completed, lessons of interest. These facts disarm criticism. The facts, however, should not be misapprehended. Requirements of the kind listed must be correctly evaluated. Until they are translated into dollars and cents their utility is uncertain. When the records of this work are complete they should include a complete cost analysis.

RELATIONS BETWEEN ENGINEER AND CONTRACTOR.

In writing and interpreting specifications the engineer has assumed certain duties and powers, some of which are being questioned with such frequency and show of spirit as to portend real danger unless the situation is met with frankness and tact. In certain matters the engineer has set himself up as law-maker and as court of final appeal, both as to the content and the intent of his specifications. He has been permitted to do this mainly for one reason—his reputation for fairness and honesty of purpose. An incidental reason has been that, in the past, contractors have not been super-critical of the engineer's work and methods. At this time—a time when engineers are beginning to take inventory and to evidence some concern in their future status—it is well to consider with care their relations with the contractor. Keen competition and a conviction that he has not always been given fair representation in matters of dispute involving work done by him have tended to make the contractor more critical and cautious. Hard work, the assumption of great risks, and the difficulty of financing his operations have also tended to place the average contractor in such frame of mind as to cause him to demand certainty of profit for work well and economically done. That the engineer has been and still is too little concerned with the relations between himself and the contractor is evidenced by the following statement by Hillis F. Hackedorn, president of the American Society of Engineering Contractors, in discussing the subject "Equitable Specifications and Contracts":

> One of the most dangerous conditions in the greater majority of specifications is the clause providing that the engineer shall be the final judge as to the interpretation of the specifications. The lawyer would call this "ex parte," for the reason that the engineer is in the employ of the owner, and his judgment is bound to be biased toward that side. Of course, I realize that the engineering profession takes the high and lofty position that the engineer's judgment will be fair to both contractor and owner, that he is, like Caesar's wife, above reproach, and that the contractor should have faith enough in him to believe that the engineer will give him a square deal; and, unfortunately the ranks of the contractors contain many who still believe that to be true. Investigation and inquiry among hundreds of contractors has convinced me that this presumed fairness and equity on the part of the engineer is the exception and not the rule.

No doubt many engineers will be inclined to ignore the above charge as being unworthy of their attention; and herein lies the real danger. It makes little difference, in its ultimate harmful effect, whether there is or is not justification for a charge of this kind if contractors really believe they are not receiving a square deal from the engineer. The engineer still holds the balance of power, and it therefore behooves him to take the initiative in diagnosing symptoms of distrust and in prescribing proper remedies for diseases found to exist. We believe much can be accomplished toward assuaging and preventing feelings of distrust by a frank discussion, say, in annual joint conferences, of the many vexing problems of mutual interest to the engineer and the contractor.

THE TREND TOWARD SELF-IMPROVEMENT AMONG ENGINEERS.

Those who feel that the solution of the engineer's welfare problem must be based on greater competency on his part should find cause for encouragement in the strong tendency to hold schools for employes of engineering departments, short courses of special instruction to practicing engineers, as given at colleges, etc. This trend toward formal or systematic study after graduation is the best sort of evidence of the desire on the part of engineers to effect self-improvement. Two illustrations of the form of study we have in mind will be given.

The Milwaukee Sewerage Commission employs about 45 engineers, of various ages, who are intrusted with duties ranging from that of rodman up to that of assistant engineer. These men meet for an hour one evening each week to read and discuss papers bearing on the problems which they encounter from day to day. These problems are those arising in connection with surveying and drafting, and the design and construction of sewage collecting and treatment works. The Chief Engineer tells us that excellent results have been secured in this school. The men have their interest in the work quickened and, desiring to appear to advantage before the chief, exert themselves to write good papers and to discuss intelligently the various papers read. The chief tells us it helps him to get a line on the relative qualifications of the men and that he has made several promotions on the strength of what these sessions have disclosed as to the abilities of the men.

A school for city engineers was held recently at the University of Kansas, under the auspices of the engineering department. It was attended by city engineers from all parts of the State. City engineering problems were discussed and the visiting engineers were given the opportunity to make tests of paving brick and other materials in the engineering laboratories. So far as we know this is the first school held for practicing city engineers.

There is nothing novel in a short course of study designed to impart a smattering of knowledge to those previously entirely innocent of it—some of the short courses in road building illustrate this point. But there is something new in the holding of a school for skilled engineers who desire to increase their knowledge of the duties they are daily called upon to perform.

The two schools we have mentioned adequately illustrate the fact that practicing engineers are coming more and more to realize that study must be continued after graduation.

LOOKING ABROAD FOR OPPORTUNITIES.

The great war in Europe has done much to jar Americans out of their long-time state of complacent provincialism. The people of the middle west have come to think of the states to the east and west as something more than buffer states. The people of the Atlantic seaboard have come to think of the back country, west of New Jersey, as a sizable chunk of land inhabited by worthy folk and almost destitute of Indians and buffaloes. Finally, the people of the south and of the real west have also caught the national spirit and look at things from the broad viewpoint of national interest. There can be no national consciousness without at least a vestige of the world viewpoint, so it may be assumed that we have the latter. With the talk of building up foreign trade, American engineers as individuals will do well to ask themselves whether they wish to go abroad for business opportunities. Those who are willing to leave this country, to live and work in a foreign country, are quite likely to have the opportunity to do so. There are many indications of this.

For example, we have just received a letter from the Bureau of Foreign and Domestic Commerce, Washington, D. C., announcing a United States Civil Service examination to be held April 5, for the position of clerk to commercial attache in foreign countries. Appointments to these positions in foreign countries will be made at a salary of $1,500 per annum. To quote from the letter:

> It is important for us to export men if we are going to make a success of exporting mechandise. I regard the clerkships to commercial attaches as the very best type of training for young men for foreign trade work. The Bureau of Foreign and Domestic Commerce expects these young men to remain abroad at least three years, and endeavors to provide suitable opportunities for advancement for the men who make good.

As we say, this is just one example of the character of opportunity we have in mind. There will be many others—both in the government service and in that of private business organizations. The young engineer who wishes to go abroad, to South America, let us say, would be justified in taking a position in a commercial organization with the plan in mind of holding the position while learning the language, the customs, etc., of the people. Whether he got into engineering work later on or not might safely be left as a problem for future solution. Very likely he would see business opportunities quite as attractive as any engineering position could be.

While the writer has never been in South America it strikes him as the place for young American engineers to go if they go abroad at all. The reasons back of this statement are clear to everyone who has read the newspapers and magazines for the last two years. Pan-Americanism may be the dream of today, but it is likely to be the reality of tomorrow.

While on this subject it occurs to us that while we are writing academically many of our readers are in position to write from experience. We believe the time is opportune for American engineers who have been in South America, and have returned to this county, to write out their views on the desirability of engineering or general business positions in that country from the viewpoint of the American engineer. Therefore we invite our readers who are thus experienced to write us short letters for publication covering this point. Correspondents are at liberty to handle the subject as they see fit. They may even "reminis" a bit if they choose.

EDITORIAL PARAGRAPHS.

Administrations of large engineering construction works usually become violently economical at the point where it is proposed to publish the engineering studies and data accumulated in planning and construction. It is noteworthy, therefore, to have announced for publication in five volumes all the analyzed data and technical investigations produced in planning for nearly three years' flood mitigation works for Dayton, Ohio, and the Miami River Valley. The value of this publication will be very great. The opportunity to make it is a good fortune that comes to but few engineers of great construction works.

In constructing the Panama Canal a great number of engineering studies were made and a vast number of data were collected which have never been and probably never will be published. The Los Angeles Aqueduct is another work of which the same facts are true. Nothing is remarked by engineers of these losses because they have become habituated to the fact. Also the engineer has become habituated to the thought that he may not suggest any different practice. One sometimes thinks that this attitude of the engineer is more responsible than anything else for the lamentable fact that the engineering history of most great construction works is buried in oblivion.

Every day, at this season, we read of at least a half-dozen cases in which the water or health department officials of well-known cities are advising people to boil the public water supply before using it to drink. We have gained the impression that such warnings are futile and we should be glad to have data to prove or disprove that belief. Such warnings salve the conscience of the authorities and appear to shift the responsibility from the city to the citizens. It is our contention that the city has no right to sell an impure water supply under any circumstances. The sense of responsibility needs quickening on this point. We hope authorities who doubt the efficacy of such warnings, but who, for the moment, are powerless to do anything more efficacious, will collect data showing that people disregard these warnings. This fact established, the proper purification of the supply should be easily and promptly attained. By the way, the spectacle of such cities as Chicago and Milwaukee going on week after week warning the individual to boil his drinking water, as they have been doing recently, is enough to make men bearing such names as those at our masthead sigh for a little of the German brand of efficiency in running a city.

The user's interest in a motor truck begins above the chassis. Fundamentally, of course, this statement is false, but from the truck marketing viewpoint it is true. The economy of motor truck haulage beyond that of horse haulage lies in quick means and conveniences for loading, unloading and conveying load. The user must know these means and conveniences to employ motor trucks successfully; he needs to know very little of chassis construction.

AUTOMOBILE TRANSPORTATION FOR COUNTY ENGINEERS.

To the Editors:

In your issue of March 22, I have noticed with interest a statement of cost of running a Ford automobile used in road construction by W. D. Maxwell, of Iowa.

A study of these figures is instructive for a person engaged in highway or other kinds of field engineering. The cost which Mr. Maxwell has computed, 6.34 ct. per mile, agrees closely with like costs by other parties. But the writer wishes to call attention to the fact that there has been no charge made for taxes, license fee, garage and interest on capital. Assuming that a temporary garage may be had for $60 (very low), and assuming that license, taxes and insurance will amount to say $30 for the three years, we have a total capital invested of approximately $750 for three years. Figured at 6 per cent (simple) interest we have a little item of $135 to add to our "maintenance" charge. This is 16½ per cent additional. Thus the total cost of running the car 20,195 miles would be $1,416.34 or an even 7 ct. per mile.

The writer believes it is inadvisable for an engineer to estimate lower than 7 ct. per mile Ford charges. In fact, it is safe to use 7½ ct. per mile to cover unknown contingencies, increased cost of gasoline, etc.

As compared to the old way of horse and democrat the Ford way is certainly the cheapest. Figured strictly on a mileage basis the horse drawn vehicle will not compare at all. For instance in the western states the usual price for hire of two horses and democrat is about $100 per month. Assuming a maximum of 20 miles per day (10 miles out and back) for 25 days per month, we have 500 miles for $100, or 20 ct. per mile! In other ways the advantage of an automobile is evident. The only drawback is in times where the roads are too muddy for motor care navigation. Allowances must be made for this contingency in selecting a type of vehicle.

Respectfully,
FRANK T. HOWES.

Copperhill, Tenn., March 27, 1916.

WHAT IS WRONG WITH THE AMERICAN WATER WORKS ASSOCIATION?

To the Editors: In your issue of March 22, 1916, you have an editorial on the subject, "What Is Wrong with the American Water Works Association?" After carefully reading your editorial, it seems to me that the heading should not be put in the form of a question, for you have certainly given the answer.

The American Water Works Association, though it has been in existence for over 35 years, "has not found itself," and has become a society for mutual congratulation rather than for mutual benefit. Until recently, the only benefit which an operating head of a small water works could obtain from attending a convention of this society, was the physical rest and vacation which he obtained by taking the trip and seeing the sights. There may be a plan to hold the annual conventions at approximately the "center of membership," but most assuredly they have seldom been held where the great body of water works men of the central and western states could reach them without considerable personal expense and loss of time. Heaven knows, the small operator needs an annual rest and seldom gets it, and if this were the principal object of the Association and the meetings were held at central points a good work in this line would be accomplished.

Lately, a Superintendent's day has been introduced and widely appreciated. I have before me an announcement to the effect that the 36th annual convention will be held in New York City from June 5 to 9, or at a time when most of the small operators are experiencing their busiest season. I note that one day will be devoted to superintendents; truly a great concession, that the ones who need a mutual benefit association should be allowed one day to discuss their mutual problems, which in the main are considered small ones. The rest of the time will probably be spent in electing officers, selecting the next meeting place, and listening to some learned papers which are way over our heads. The speakers will be highly trained technical men who do not understand nor care to take up, except in a bored, patronizing way, the vital problems of the small operator.

It is well that the several geographical groups of the United States are organizing their membership into sections for at a sectional meeting, the members can actually get together and swap cigars and experiences and from such meetings real benefits are derived and a fraternal spirit fostered.

The solution of the American Association difficulty it seems to me is to get down to a "brother to brother" basis and then the membership will not be limited to eight per cent of the active heads of water works.

Very truly yours,
AN IOWA WATER COMMISSIONER.

WATERBOUND MACADAM ROAD RECONSTRUCTION IN RHODE ISLAND.

Contributed by T. W. Patterson, Chief Engineer, State Board of Public Roads.

The big problem of this state in road work is the reconstruction of old waterbound macadam roads which have proved to be altogether inadequate for the traffic to which they are subjected today. We have at the present time 325 miles of road constructed by state funds and maintained by state funds. Of this 325 miles of road 234 are of waterbound macadam and the remaining 91 are of bituminous macadam construction.

Our last general inspection trip made in the fall of 1915 indicated that 66 miles of state road were completely worn out, that 110 miles in addition to the miles worn-out showed very noticeable defects and that the remaining 149 miles were in good condition.

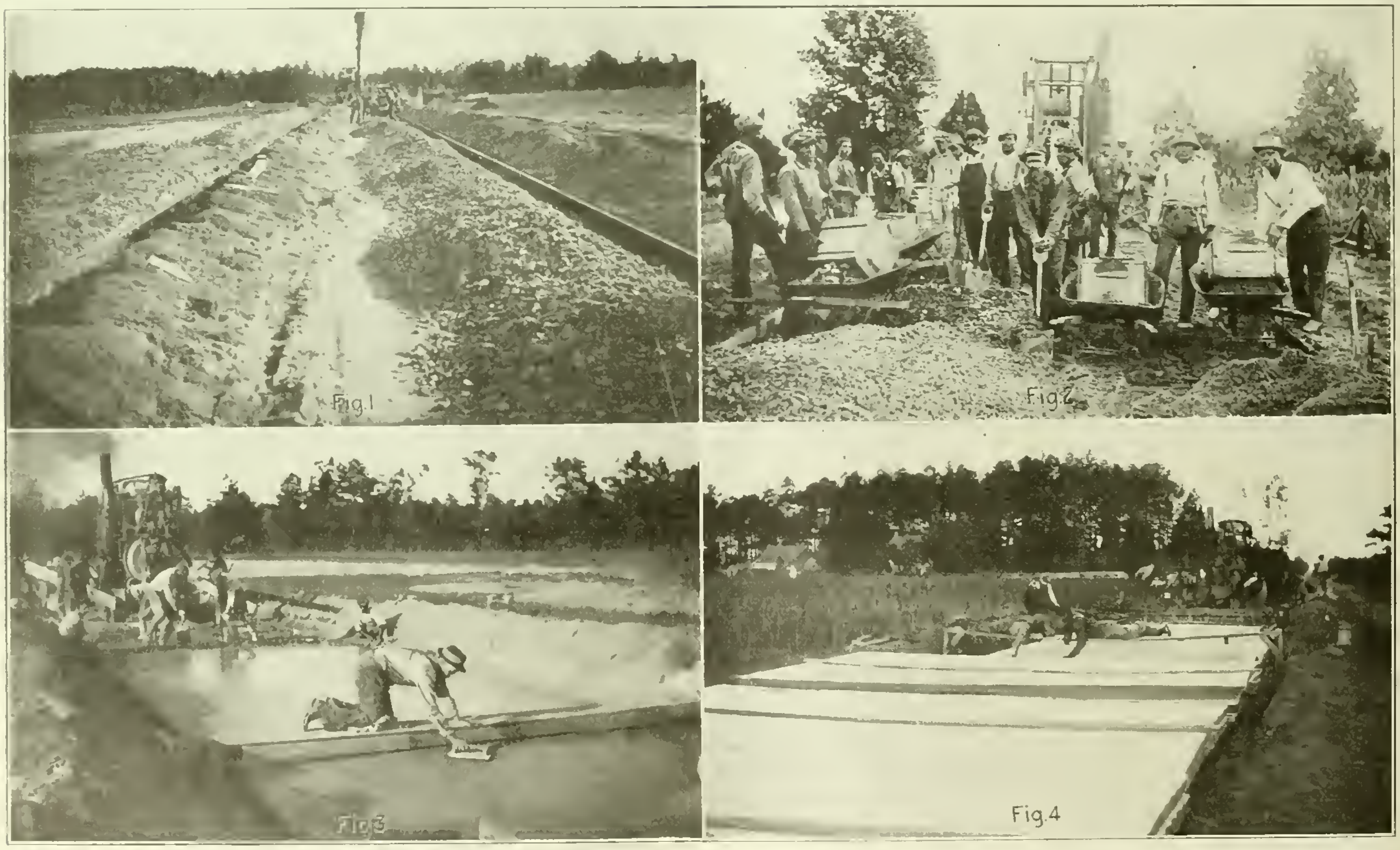
We anticipate that funds amounting to about $200,000 will be appropriated in 1916. This amount, together with the net receipts secured from the licensing of automobiles, will make our total available funds approximately $400,000. The funds secured from licensing motor vehicles must by law be spent for maintenance, and we anticipate that the appropriation which is pending in the Legislature will be for reconstruction only.

It is our general plan in 1916 to reconstruct every main road that it is possible to reconstruct without seriously interfering with the general repairs which are constantly demanded. We expect that all of this reconstruction will be upon our six main trunk lines. As we do not know exactly what our funds are to be we cannot well make definite plans of work, but the preceding statement of the condition of our roads and of the general manner in which we expect to spend whatever funds are available, may be of some interest.

METHODS OF CONSTRUCTION ON THE COLEMAN-DUPONT CONCRETE ROAD.*

By Charles Upham, Chief Engineer, Coleman-DuPont Road, Inc., Georgetown, Del.

During 1915 work was commenced on the southerly 20-mile section of the Coleman-DuPont road. The present construction begins at the Maryland line, and as fast as the right of way is obtained the road will be extended through the central part of the state of Delaware to the Pennsylvania boundary. Approximately 55 per cent of the present construction was completed before cold weather, and it is estimated that, with the six mixers now ready for work, the remainder of this section can be completed in 1½ months.



CONSTRUCTION VIEWS ON THE COLEMAN-DU PONT CONCRETE ROAD, DELAWARE.
Fig. 1. Form Alinement and Distribution of Concrete Materials.—Fig. 2. Mixer Charging Gang Using Measuring Boxes.—Fig. 3. Hand Finishing Road Surface.—Fig. 4. Canvas Protective Covering for Finished Concrete.

The alignment is practically straight, averaging only one curve in every 4 miles. The curves are of large radii, thus making less apparent the deviation from a straight line. The longest distance between curves is about 12 miles; the shortest distance is a little over one mile.

In general the grades are slight, there being only one grade on the section now under construction that exceeds 1 per cent.

Drainage.—The flat country made it necessary that especial attention should be paid to drainage. A complete drainage survey was made, which comprised the locating and taking elevations on all existing ditches and streams that crossed the DuPont road, or which were near enough to serve as a part of the drainage system. The area of this survey generally extended one-half mile each side of the road, but in few instances where the country was exceedingly flat elevations were taken in ditches three-fourths of a mile from the road. With the help of this drainage survey a satisfactory drainage system was obtained. The drainage principle that was followed was to get the water off and away from the road as soon as possible.

---

*Abstract of a paper read at the Chicago meeting of the American Concrete Institute.

Generally speaking, the surface soil along the DuPont road is sand or clay or a mixture of these, but in some instances the road traversed swamps and depressions where the surface consisted of a black muck that became very hard in dry weather, but when wet became very soft and slimy. This black soil was capable of absorbing and retaining a large quantity of water. For this reason the greater part of this soil was removed and replaced with a more suitable material.

In general, the swamps were drained and stumps removed before the fill was deposited. In one instance, however, if this was done the cost would have been excessive, so the fill was made directly on the surface of the swamp, which was floating on about 5 ft. of black muck, underlaid with a solid foundation of sand and bog ore. It was thought that the weight of the fill, which was approximately 5 ft. deep, would be of sufficient weight to settle it to firm foundation. This was found to be otherwise until holes were cut through the surface of the swamp near the toe of the fill to allow the weight of the fill to force the muck up through the holes. This allowed the fill to settle to a firm foundation. Approximately $1,500 was saved by this operation. The fills were made in 8-in. layers, each layer being rolled before the next was placed. If the material was drifting sand, sufficient clay was added to enable the compacting of this sandy material and also to keep it in place.

Grading.—The grading in practically all cases was light. In general, the subgrade was left about 2 in. high, and was rolled thoroughly with a roller weighing not less than six tons. Often it appeared that the roller would break up the subgrade rather than compact it, but after this loose material was shoveled off it left a smooth, compact subgrade, showing the roller to have broken up the surface of the subgrade but to have compacted it underneath.

The road surface on the section now under construction consists of one mile of waterbound macadam, one mile of bituminous pavement and 16.4 miles of plain and reinforced concrete.

Concrete Construction.—The concrete pavement was constructed, 14 ft. wide, 7 in. deep in the center and 5 in. deep on the sides, on a flat subgrade. The proportions of the ingredients used in the concrete were 1 of cement, 2 of sand and 4 of stone. Hydrated lime was used in various quantities, according to the different experiments that were made. Each batch of concrete was mixed for 1½ minutes. The subgrade was wet before the concrete was deposited and care was taken that all batches were thoroughly spaded together, so that a homogeneous mass might result.

No standard length of slab was adopted, as it was decided that, in order to learn what the maximum length of slab could be, joints should be placed only when the concrete mixer stopped for more than 15 minutes. This resulted in some very long slabs, the longest being 460 ft. Transverse cracks have appeared in the longest slabs, and because these cracks occurred at regular intervals, and knowing the subgrades, materials and construction to be especially good, it would seem that practically all of these cracks were due to contraction and followed a regular principle. This will assist in determining the maximum length of slab possible to construct, without transverse cracks, to meet the future requirements of the DuPont road. Armor protection plates were used at each joint.

Reinforcement.—The greater part of the pavement is reinforced, the reinforcement being placed 2 in. from the surface in each instance. The reinforcement did not prevent the transverse cracks entirely, but has probably reduced them in number. No longitudinal cracks have appeared. While it is intended to use five different kinds of reinforcement on this section, only three different kinds have been used up to the present time. In deciding on the different reinforcement to use it was the intention to keep the cost and the weight per square yard as nearly the same as possible. One part of the road is reinforced for the entire width with No. 29 American Steel & Wire mesh reinforcement. This gives the weight of reinforcement in each square yard of pavement as 2.52 lb. Wherever the slab is less than 178 ft. long no cracks have yet appeared. Another part of the road is reinforced for the entire width with No. 25 Khan expanded metal. This gives the weight of reinforcement in each square yard of pavement as 2.25 lb. Wherever the slab is less than 164 ft. long no cracks have yet appeared.

Another part of the road was reinforced with No. 25 Khan reinforcement for a distance of 4 ft. each side of the center line. More cracks appeared in this section than where the reinforcement extended the entire width of the pavement. Another section was reinforced with the same reinforcement for a distance of 3 ft. each side of the center line. With the exception of one slab, more cracks have appeared in this section than in either of the other reinforced sections. The section where no reinforcement was used has developed cracks, but up to the present time not as many as the sections that were reinforced with the 6-ft. and 8-ft. reinforcement. One reason for this may be that this unreinforced section has not been laid as long as the others. Lighter reinforcement of the same type has been used, but these slabs have not been inspected recently. With one exception, it appears that as the percentage of reinforcement increases the transverse cracks become fewer. The increased cost due to reinforcement was 9 ct. per square yard. If the reinforcement was not used and the money put into concrete it would add but ½ in. to the thickness of the road.

Finishing.—On one of the sections a power templet was used to finish the concrete. This left the concrete smooth and with an even surface. It was also claimed that this machine compressed the concrete. This may help to resist the abrasive wear, but has not up to the present time prevented or reduced the transverse cracks. On the other sections the templets were made from 4x4x½-in. angle iron, bent to conform to the crown of the road. After the laborers learned how to use these they worked very satisfactorily. If it could be avoided. the templet was not drawn over the pavement more than once, it afterwards being finished with hand floats made of wood or cork, care being taken to disturb the concrete as little as possible after it was laid in place. This precaution resulted in the stone aggregate being very near the surface, or in other words, in there being very little matrix or mortar above the stone.

Immediately after the concrete was finished wooden frames covered with canvas were placed over the concrete, to protect it from the sun or wind. These were kept on the concrete for about 24 hours, after which the concrete was covered with earth for a depth of 2 in. and kept wet for a period of 14 days. After 30 days this covering was removed and the concrete allowed to harden for two weeks before traffic was allowed on it.

Concrete Materials.—Great stress was laid upon the securing of satisfactory materials for the concrete. After considering various aggregates, it was seen that it was economical to use crushed trap rock; the requirement being that it should have a French coefficient of wear of at least 17 and should be the run of the crusher that would pass a 1½-in. ring and be retained on ¼-in. ring. Tests showed the average French coefficient of wear to be 17.7 and the voids to be 45 per cent. The stone was shipped from Pennsylvania, a distance of over 100 miles.

There is much sand in the surrounding country, but it was decided, after many tests, that none of it was suitable for concrete work. The sand finally used was a dredged river sand of exceptionally good quality. This was loaded on cars and shipped about 90 miles. The grading of this sand was especially good, the large particles being nearly ¼ in. in size. By using this sand with the trap rock aggregate we secured an exceptionally good grading of the concrete ingredients, from 1½-in. pieces of stone to the fine particles of sand.

All the cement came from the Legigh Valley district and passed the standard requirements of the American Society for Testing Materials.

With but two exceptions the water used in the concrete construction was obtained from driven wells; in one instance it was obtained from a mill pond, in the other from a small stream. The tests showed this water to be as good as the well water.

Testing Materials.—All the materials were tested and inspected by the Bureau of Inspection, a department of the Coleman-DuPont Road, that for the past three years has been given over to testing materials, experimenting and research in highway methods and materials. The stone was inspected at the quarry. The sand was sampled and inspected when loaded on the cars, the tests being completed while the sand was in transit. The cement was tested and inspected at the cement mill. By this method of testing all materials were ready to use as soon as they arrived at their destination and no delays were caused by rejected materials. All water that was used in the concrete was tested each week.

Besides these various tests there was also a testing engineer, making sieve analyses of the stone and testing the sands for voids, making slight changes in the proportions of the ingredients if found necessary. The testing engineer took samples of stone to determine its toughness and also took samples of sand and cement to be sent to the laboratory for a check test. A few concrete samples were taken and crushed at the laboratory of the Bureau of Inspection. These were taken mostly to determine just what increment of strength was obtained by increased mixing of the ingredients. The testing engineer was not only to check up the quality of the materials but also to keep complete records of the quality of all materials.

Hydrated Lime.—A number of experiments, using different amounts of hydrated lime up to 10 per cent by volume, were performed. The lime was placed in the hopper with the other ingredients. While sufficient time has not elapsed to draw any definite conclusions, the results promise to be interesting. The only conclusions that can be drawn now as to whether or not the lime is of benefit is from the number of transverse cracks that have developed. On one section where no lime was used the longest reinforced slab that has not developed a crack is 191 ft. When 10 per cent of lime, by volume, was used the longest slab to develop no cracks was 210 feet. In another instance a slab without reinforcement and using no lime has developed two cracks, breaking the slab up into three slabs of 299, 118, 126 ft. In two slabs where 10 per cent lime was used no cracks have yet developed. The length of these slabs are 336 ft. and 210 ft.

On another section the longest slab without lime showing no cracks is 187 ft. When 5 per cent lime was used the longest slab without a crack is 245 ft.; when 10 per cent of lime was used the longest slab showing no cracks is 294 ft. While this is not sufficient data from which any definite conclusions can be drawn, it does, however, advocate the use of lime. Much more experimenting will be done along this line, and at the present time the Bureau of Inspection is carrying on quite extensive laboratory tests with cement mortars, with and without the addition of lime.

Circular letters were sent to five resident engineers and three inspectors who never had any experience with the use of lime, asking them to give their opinion in regard to its use. In all but one instance the replies advocated the use of lime. In each instance the lime was claimed "to make the concrete more plactic"; "to delay the set"; "to make it easier to draw the templet," but "harder to hand float the surface, as it made the matrix 'stickier.' "

Inspection.—The work was very carefully inspected by men who had had considerable experience. Previous concrete road experience was taken into consideration and the requirements of the specifications were practically standard, with the exception of the time of mixing, and a few other little details. The contractors were obliged to use bottomless measuring boxes in order that they might use the exact quantities of stone and sand in each batch of concrete. It was difficult to secure exactly the same consistency of all batches, partly on account of the varying amounts of moisture in the aggregates and partly to the water control on the mixers.

More extensive experiments relative to reinforcement, use of lime, distance between joints, etc., will be resumed as soon as the work commences in the spring.

PREDOMINANCE OF MAINTENANCE WORK IN PENNSYLVANIA IN 1916.

Contributed by W. R. D. Hall, Statistician, Pennsylvania State Highway Department.

The Pennsylvania State Highway Department, in planning for the 1916 season, was confronted by the same difficulties which obtained in the 1915 work. The highway system, controlled by the Pennsylvania State Highway Department, is 10,200 miles; this mileage consists of roads taken over from the townships and counties by legislative enactment in 1911 and 1913 and renamed as State Highways under the exclusive jurisdiction of the State Highway Department as to construction and maintenance. The formation of the State Highway Department in 1911 and the enactment of a law thus taking over these highways was predicated upon the passage of an amendment to the State constitution permitting the creation of a $50,000,000 loan for highway construction purposes. This proposal was voted adversely upon by the people in 1913 and, as a result, the State found itself saddled with the whole expense of the maintenance and construction of this 10,200-mile system without adequate revenues to finance this vast project. The defeated constitutional amendment cannot be resubmitted to the people until 1918. Therefore, it has been necessary to use such revenues as have been appropriated by the legislatures, since 1913, for the purpose of maintaining this vast mileage of roads.

The problem which has confronted the State Highway Department forces, hence, has been almost exclusively one of maintenance. The Legislature of 1915 made an appropriation of $8,300,000 for all purposes of the State Highway Department during the succeeding two years, or until June 1, 1917. Of this sum $6,000,000, or $3,000,000 a year, was designated for the construction, maintenance and repair of State Highways. As the State Highway mileage is 10,200, this figures down to less than $300 a mile a year for these purposes. One million five hundred thousand dollars of the total appropriation, given above, was designated for the repayment to the townships of a cash tax bonus, as provided by a law which says that townships making a cash tax collection shall be reimbursed by the Commonwealth on the fifty-fifty basis, provided the amount thus reimbursed does not exceed $20 a mile of roadway in the respective townships. Of the total appropriation $500,000 was for the purpose of State-aid, whereby the State sustains 50 per cent of the cost of highway improvement, the remaining 50 per cent being paid by the counties and townships applying for State aid. An appropriation of $50,000 was made for the repair and improvement of the Old National, or Cumberland Road, the only highway ever built by the Federal government, a portion of which runs through Pennsylvania. Also $250,000 was set aside in the general appropriation for the purchase and condemnation of toll road turnpikes.

As a result of these conditions, the work of the State Highway Department during 1915 and 1916 has been and will be, as said before, largely maintenance, but there has been and will be a certain amount of State-aid construction attempted.

THE PLANS AND ACCOMPLISHMENTS OF THE NEW NORTH CAROLINA HIGHWAY COMMISSION.

Contributed by W. S. Fallis, State Highway Engineer, Raleigh, N. C.

The State Highway Department of North Carolina, organized in May, 1915, has in the short period of time since it was organized, in addition to the many details of its organization, taken up the following work:

The development of a standard of procedure in which it wishes to establish rules for and under which it will render the assistance, as authorized by the law, to the various counties of the state; rules whereby each county will be dealt with on a fair and equitable basis, giving preference to no county or section of the state, no matter what the influence might be that could be brought to bear, and arranging the machinery for this distribution of service in such a way that it might be evident to the inquiring public that such rules as established had been in all cases rigidly adhered to.

It is also the purpose of the Commission to arrange, as soon as possible, for the publication of standards for roads, bridges and culverts, also for the publication, from time to time, of maps showing the road systems of the counties and state. These maps will be in sufficient detail to serve as a guide for travelers in visiting any part of the state or any section of a county.

Since the organization of the department, in May of last year, between 40 and 45 counties of the state have applied to the department for assistance under some form or other, varying from complete supervision of the work in the county or township to simply giving lectures or advice, and this assistance has embraced counties from Cherokee in the southwest to Currituck in the northwest, and from New Hanover in the southeast to Ashe County in the northwest, having given some form of assistance in the counties occupying the four corners of the state.

We have been endeavoring to place, so far as we have been permitted to do so, the bridge work of the state on a more business-like basis. The usual conditions of the highway bridge work has prevailed here as in many other places where the bridge contractors have supplied counties with plans, as well as prices, with the resulting lack of real competition and poor bridges, waste of money and dissatisfaction. Where satisfactory prices could not be obtained for work done under plans made by the State Commission, the Commission has taken over the construction of bridges for the counties, with the result of better bridges and a large saving in money to the counties. We hope to get this part of our work in such shape that contractors for this work will be in position to give the lowest possible prices on plans furnished by the Commission with full assurance that fair and just treatment will be accorded each bidder. This means will result, we hope, in entirely eliminating, on the part of counties, the "auctioning" of their bridge work, and on the part of the bridge contractors the "pooling" of their bids, as this practice is as reprehensible on the part of one as on the part of the other, and results in poor work always and means frequently a loss to both parties concerned.

We are proposing to pay particular attention during the year to maintenance schemes, and have already planned and established such projects in several counties. We have in hand the general idea of a system of state maintenance for the roads that would be called state roads, including finally all the inter-county roads, gradually linking up all the county seats into a system connecting with the through roads, all to be maintained under the supervision of the State Commission with money derived from some general state fund properly applicable to such purposes; such a system of inter-county roads connecting with such through highways as the National Highway through the western part of the state, the Washington-Atlanta Highway through the eastern part of the state—both roads being through roads north and south—the Central Highway, the Charlotte-Asheville Highway, the Charlotte-Wilmington Highway, running east and west, would soon form, under proper maintenance, not only such a system of continuous good roads for the entire 365 days of the year, as we have been dreaming of, but would give to the counties of the state an object lesson on the value of maintenance that would be invaluable.

The Highway Commission is soon to have the needed equipment for testing materials most used in the road work of the state, such as soils for surfacing roads, sand for sand-clay roads, clay for the same purpose, and cement and sand for concrete used in roads and bridges.

The immediate work now being carried on under the direct supervision of the Commission, and worth mentioning here, is a proposed patrol system for maintaining the Central Highway from Beaufort, N. C., on the coast, to the Tennessee line west of Asheville, in the mountains—a distance of more than 400 miles. An itinerary in co-operation with the United States Office of Public Roads and Rural Engineering will be conducted over the route during April, in order to secure the co-operation of the various counties along the route.

There are also three other through road projects being conducted by the State Commission. Surveys are now being made on a road to connect Wilmington, N. C., with Fayetteville, N. C., through the counties of New Hanover, Pender, Sampson and Cumberland; the road to be known as the Wilmington-Fayetteville Highway, and will connect with the Washington-Atlanta Highway at Fayetteville.

Surveys are also being made on the road known as the Charlotte-Wilmington Highway, a state highway approved by the Legislature several years ago.

The third is a highway to be known as the Charlotte-Albemarle-Pinehurst Highway, which will be surveyed soon. This road passes through the counties of Mecklenburg, Cabarrus, Stanley, Montgomery and Moore, connecting Charlotte directly with the noted winter resort in the sand-hill region of the state.

The Commission has under direct supervision and control the construction of two bridges of reinforced concrete—one of them 370 ft. in length in Franklin County, and one 450 ft. in length in Edgecomb County, besides a number of smaller steel and concrete bridges.

OFFICE METHODS FOR A SMALL CONTRACTING BUSINESS.

Contributed by C. M. Cobb, Decatur, Ill.

The subject of office methods for a small contracting business is one which should deeply interest every contractor who keeps record of his business transactions other than his pass book and canceled checks.

It is a subject which has been touched upon in a few articles, but I have never had the privilege of seeing a description of a practical scheme for handling office work that would apply in its entirety to the business of a contractor who handles from $50,000 to $250,000 worth of work annually.

There are any number of books and articles on office methods for large factories, for steel mills, railways, and big business in general, but very few that could be applied practically to a business of the nature mentioned above.

In the following paragraphs I have attempted to set forth briefly and clearly the methods employed in handling office work of a firm employing only one man in the office.

In describing these methods, I have intentionally omitted several phases, such as purchasing, estimating, etc., for the reason that in this office, as is generally the case, these matters are handled personally by the contractor.

For the purpose of more clearly describing those features of office work which I propose to cover briefly in this article, I have divided it into three sections, as follows: (1) Accounting. (2) Cost Keeping. (3) Correspondence.

Accounting.

Journal and Ledger.—We use the standard double entry system of bookkeeping in our office, with the regular bound journal and loose-leaf ledger. There are doubtless many contractors who prefer the single entry system of bookkeeping on account of the additional work required in handling double-entry books, but we find it essential in our business to use the double-entry system. It is certainly a far more satisfactory way of keeping accounts where any accuracy is demanded, in spite of the greater amount of time required in using this system.

We do not carry a separate set of books for each contract, as is necessary under the single entry system, but carry all of the general and contract transactions through the general ledger.

We carry a separate account in the general ledger for each contract, showing expenses and receipts. We carry a separate account for each item of expense which is not directly chargeable to any particular contract, and endeavor to divide these general expenses into their proper headings for purpose of comparison and analysis. For example, following are subdivisions of general or overhead expense for which we carry separate accounts on our ledger:

Auto expense.
Advertising.
Fire insurance.
Interest.
Office supplies.
Office salaries.
Prospective work.
Real estate maintenance.
Repairs and renewals.
Salary of officers.
Telephone and telegraph.
Taxes.

Various Depreciation Accounts, Etc.—These accounts, of course, would not apply to every concern, and can be altered as may be necessary in each individual business.

This ledger contains also the accounts with our material men, etc., and accounts with our debtors.

On the 10th and 20th of each month we make up a statement showing accounts and notes payable, pay rolls and other obligations which we estimate we will have to meet by a certain date; also accounts and notes receivable, etc., and our cash balance.

This gives us twice a month an intelligent understanding of just how we stand, so far as immediate liabilities and cash assets are concerned.

Once a month a trial balance is made and a statement produced showing assets and liabilities, accounts receivable, accounts payable, and profit and loss on each contract, insofar as this information can be reached without taking inventory.

Once a year we take inventory of all equipment, tools, materials, etc., and correct on our books the accounts affected by this inventory, and are then in position to close the books for the year.

Voucher Register.—We endeavor to pay all obligations by our standard form of voucher check, and use a stock form of voucher register for the purpose of recording these payments. This register shows the date, number and amount of each voucher written; the name of the payee, the contract or account chargeable, and the deposits in the bank and daily cash balance.

This voucher register is checked once a month with the pass book and a reconciliation statement made showing checks that have not passed through the bank at the time the pass book was balanced.

Through this voucher register, all payments that are made direct, without being run through the journal, are charged into the ledger for the particular contract or other account involved.

This voucher register requires a little more work than filling out the stubs of a check book, but it is a very valuable record of the business of the company, for it shows in clear, concise, tabulated form a record of all receipts and disbursements and distribution of same, that are made by vouchers.

Vouchers.—We use a standard voucher form adapted to our particular requirements, as shown in Form 1.

These vouchers are numbered and made out on the typewriter, and the name of the bank on which voucher check is drawn is stamped on the face of the check portion with rubber stamp. The vouchers are perforated so that the check portion may be detached and run through the bank, while the voucher portion is receipted and returned by mail to the office of the company. The check, when cancelled, is returned by the bank.

Since the information shown on the invoice or statement is embodied in the voucher portion of this voucher check, we do not require dealers to send us receipted invoices or statements. The returned voucher, when properly receipted, is all the receipt necessary.

These receipted vouchers and cancelled checks are filed in document files arranged numerically for ready reference.

So far as feasible, we pay all bills by vouchers, but where this is not practical, we instruct the superintendent in charge of a contract, or the clerk in the office, as the case may be, to pay these bills by ordinary checks, from a checking account which they are furnished by the company. These checks are reported regularly to the central office and are entered in the journal instead of being run through the voucher register, and these checking accounts are replenished as necessary.

Orders.—Our instructions to foremen or superintendents are that an order must be given for any material purchased by them for the work. This applies to such tools, lumber, nails, and other miscellaneous supplies that are needed from time to time and which can be purchased to advantage in the locality where the work is being done.

For this purpose, we use a "Reynolds American Repeating Order Book," size 4x7 in., in which there are three copies of each order—one on white paper for the dealer, one on manila for mailing to this office, and a tissue copy which remains in the book.

Office copies of all orders are mailed to the central office each night with the daily report, and are filed numerically for each contract and checked against the invoices as they come in.

We stamp our name at the top of these orders and also at the bottom, with a space for the signature of the foreman or superintendent, as the case may be.

Invoices.—Our general instructions are that dealers shall send invoices direct to the central office, and show after each item the order number covering same. This last stipulation is not rigidly enforced, especially with a small dealer or individual with whom we have only one or two transactions, but we secure this information from the larger dealers without much difficulty.

Upon the arrival of the invoices at the central office, they are checked with the orders as to price, extensions, footings, etc., and in case of any doubt as to their accuracy are returned with an accompanying letter to either the superintendent or the dealer, for further information. If the invoice is found to be correct, we stamp it with a rubber stamp as shown in Form 2, and fill in the data indicated by this stamp. The invoice is then ready for payment or entering on the journal for future payment.

Generally speaking, we make it a point to voucher on the 10th of the month all small accounts received since the first of that month. Such invoices are carried in open file and no book entry is made unless it might be necessary to distribute the expense on any one invoice to several accounts.

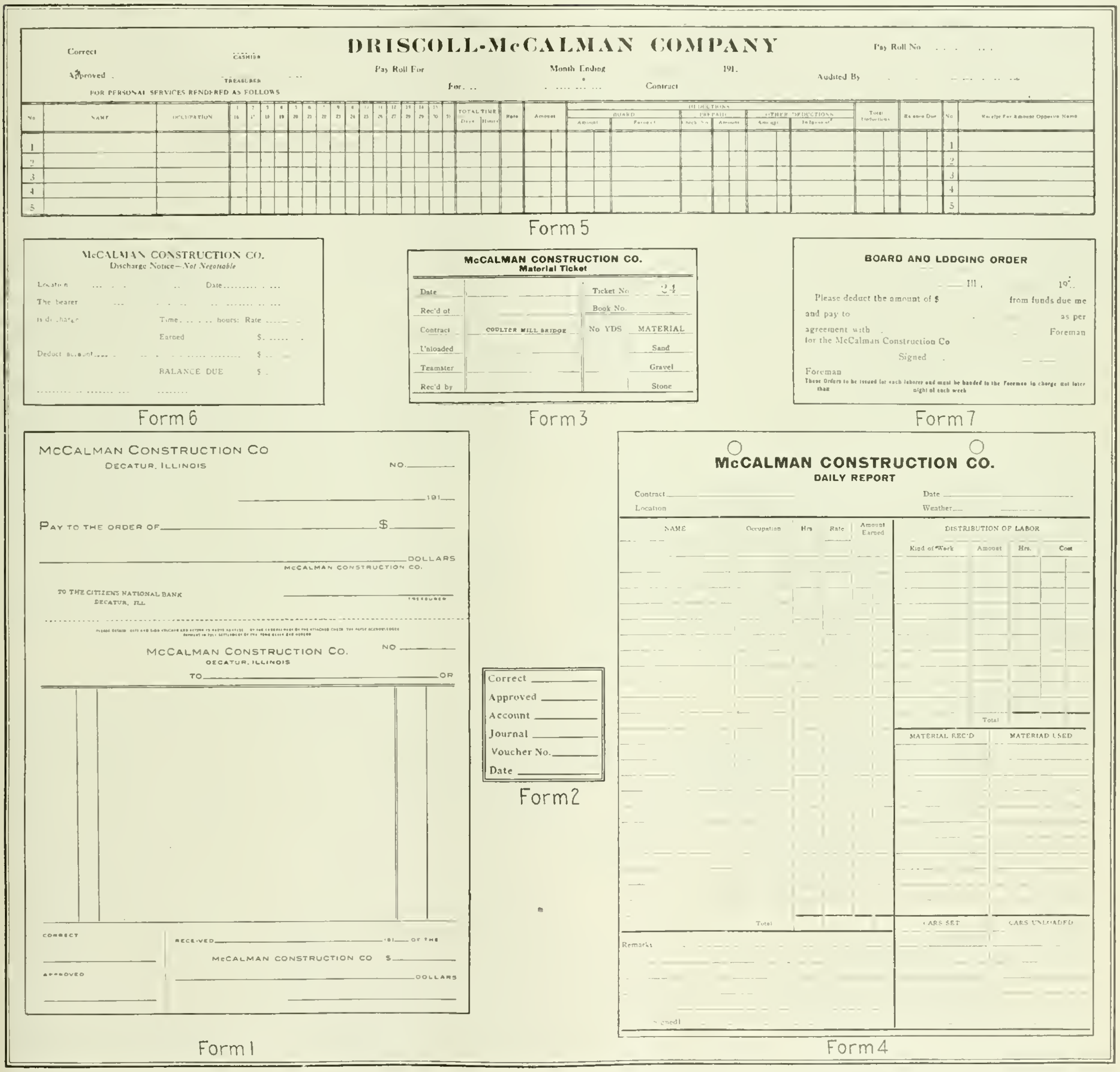
The larger invoices are entered in the journal as they come in to the central office, for payment the 20th of the month following the month in which the material is received.

We file all paid invoices alphabetically in folders, and at the end of the year paste them into invoice books, in proper order both as regards the name of the dealer and the date of the invoice. We are now working out an arrangement whereby the invoices are filed on manila cardboard backers and placed in regular vertical invoice files, as the invoice books are not only cumbersome and expensive, but require considerable time in indexing, pasting, etc.

Except in the case of force account work, i. e., work which is done on a cost plus percentage basis, we do not require duplicate invoices.

Material Tickets.—On many contracts, we find it advantageous to purchase local sand, gravel, stone, etc., instead of having it shipped in by railroad. In order to keep an accurate check on the receipt and distribution of such material, we have made up a special form of material ticket, as shown in Form 3.

This ticket book contains 25 sets of triplicate tickets, in three colors—white, blue and manila. The white ticket is given to the teamster delivering the material; the blue ticket is sent in to the central office each night; and the manila ticket is left in the book until the book is used up, when the book is filed in the local office or sent in to the central office, depending upon conditions prevailing on the particular contract involved.



DRISCOLL-McCALMAN COMPANY
Correct
Cashier
Approved
Treasurer
For personal services rendered as follows
Pay Roll For
Month Ending
191
For
Contract
Pay Roll No.
Audited By

No.	Name	Occupation	1 16	2 17	3 18	4 19	5 20	6 21	7 22	8 23	9 24	10 25	11 26	12 27	13 28	14 29	15 30	31	Total Time Days	Total Time Hours	Rate	Amount	Deductions Board Amount	Deductions Board Period	Deductions Prepaid Check No.	Deductions Prepaid Amount	Other Deductions Amount	Other Deductions In favor of	Total Deductions	Balance Due	No.	Receipt For Amount Opposite Name
1																															1	
2																															2	
3																															3	
4																															4	
5																															5	

Form 5

McCALMAN CONSTRUCTION CO.
Discharge Notice—*Not Negotiable*
Location
Date
The bearer
is discharged
Time ...... hours; Rate
Earned $
Deduct account $
BALANCE DUE $

Form 6

McCALMAN CONSTRUCTION CO.
Material Ticket
Date
Ticket No. 24
Rec'd of
Book No.
Contract COULTER MILL BRIDGE
No. YDS MATERIAL
Unloaded
Sand
Teamster
Gravel
Rec'd by
Stone

Form 3

BOARD AND LODGING ORDER
Ill., 19
Please deduct the amount of $ from funds due me and pay to as per agreement with Foreman for the McCalman Construction Co.
Signed
Foreman
These Orders to be issued for each laborer and must be handed to the Foreman in charge not later than night of each week

Form 7

McCALMAN CONSTRUCTION CO
DECATUR, ILLINOIS
NO.
191
PAY TO THE ORDER OF $
DOLLARS
McCALMAN CONSTRUCTION CO.
TO THE CITIZENS NATIONAL BANK
DECATUR, ILL.
TREASURER
McCALMAN CONSTRUCTION CO.
DECATUR, ILLINOIS
NO.
TO OR
CORRECT
APPROVED
RECEIVED 191 OF THE
McCALMAN CONSTRUCTION CO $
DOLLARS

Form 1

Correct
Approved
Account
Journal
Voucher No.
Date

Form 2

McCALMAN CONSTRUCTION CO.
DAILY REPORT
Contract
Date
Location
Weather

Name	Occupation	Hrs.	Rate	Amount Earned
Total				

DISTRIBUTION OF LABOR

Kind of Work	Amount	Hrs.	Cost
Total			

MATERIAL REC'D	MATERIAL USED

CARS SET	CARS UNLOADED

Remarks
Signed

Form 4

Seven Forms for Contractor's Cost Keeping System.

of considerable duplicated work, as by using carbon paper, all three copies are made at one writing. This scheme also insures accurate copies of the original ticket.

As these tickets come into the central office, they are sorted and listed and a running account kept of them showing the ticket number, date, name of material man, kind of material, quantity, point of distribution, etc.

We have used these tickets to great advantage on long stretches of pavement or road work, where the item of distribution is pretty important on account of the long haul.

Daily Reports.—We have arrived at our standard form of daily report, which is shown in Form 4, through three years of experiments and study and believe that it is very nearly correct for our purposes.

In this way, it is possible to know in the central office each day just what materials of this nature were received during the preceding day; who delivered them, and where they were distributed. It enables the clerk in the office to intelligently figure what amount is then owing for materials so delivered and gives the contractor an opportunity to figure what additional material, if any, is needed at the different points of distribution.

No payments are made to the men furnishing such local materials, except upon presentation of the original white material tickets.

This plan relieves the foreman or superintendent who is reporting the receipt and distribution of such material

It covers the daily time for each man, the distribution of the total labor for the day; the amount of each kind of work done during the day; material received, material used; cars set, and cars unloaded.

We insist on a separate daily report for each contract, even when one gang is working on two jobs the same day.

This report is mailed in to the central office each night.

From the daily report, we figure the pay roll as well as the total and unit labor costs. We keep a check on the material received and used, and on cars set and unloaded.

Upon the completion of a contract, these daily reports are bound between two 8½x11-in. manila postcard stock binders, and indexed and filed for future reference.

Pay Roll Form.—We have adopted a pay roll form which has answered our requirements for several years, without change. It is illustrated in Form 5. Of course, there are minor changes and additions that might be made on this form, several of which we intend to make when the present supply of these forms is exhausted. All pay rolls for completed contracts are filed chronologically for each contract.

Discharge Orders.—We use a discharge order as shown in Form 6, for the purpose of notifying the superintendent or clerk whenever an employe is discharged. This order is handed by the foreman to the employe, who presents it at either the local or central office (as the case may be) for payment. As this order is not negotiable, it precludes the possibility of paying twice for one man's work as might be the case with a negotiable order. This order shows any deductions to be made for board, lodging, etc.

Board and Lodging Order.—This is a simple form of order on the company for the board and lodging of the men whose board we guarantee. This form is not used on any city work where the men can board themselves or pay their own board, but we have found it a necessity on work in the country where boarding accommodations are limited. (See Form 7.)

These orders are turned in each pay period in time to make proper deductions on the pay roll.

Costs.

Labor Costs.—We endeavor to secure on the daily report each day the amount of each different class of work done on each contract and the total labor charge for the same. From this information, we figure the unit cost of each kind of work on each contract for that day.

We have a columnar book in which we carry forward this information each day for each class of work on all contracts, showing the total labor each day, total labor to date, overhead expenses each day, total to date, etc., and the daily and total charges and amount of work done for each class; also the unit cost of the work for the day and the average unit cost to date.

There is generally a slight variation between the labor as shown on the daily reports, and as written on the pay rolls, but the discrepancy is so small that it does not affect the unit costs enough to be of any importance.

Sub-contract work is generally done on a unit basis, and is reported roughly in a separate letter each day, with general report of the progress of the work. Since this work is done on a unit basis, it is not necessary to figure any unit costs for the subcontract work as it progresses.

Material Costs.—It is much more difficult to keep an accurate account of the amount of each of the various kinds of material used each day on each class of work on a contract than it is to keep the correct labor distribution. In fact, after once figuring the amount of material necessary for a given unit of work where the same proportions are specified, there is no very great variation, and it would necessitate practically useless expense in a business of this size to endeavor to keep a daily record of this nature.

We do, however, insist on knowing each day the quantity of each kind of material used if this information can be gotten without going to too much trouble. For instance, we expect to have shown on the daily report the number of sacks of cement used that day on each class of work; the amount of reinforcing steel; tile; castings, and any similar materials which can be easily reported. In concrete work, it is practically out of the question to report definitely the number of yards of sand, gravel or stone used by actual measurement, but this can be figured very closely from the amount of cement used and the mix specified.

If the daily reports show that too much material is being used, the matter is investigated and corrected.

Since the unit cost of the material itself is shown on invoices and most of our hauling is done by contract, it is very easy to figure what the material end is costing. We do not attempt to keep any tabulated record of the unit material costs until the end of the job. These costs I will touch upon shortly.

Overhead Costs.—In addition to labor and material costs, there are certain expenses contingent upon each contract which are usually chargeable to the entire contract and not to any one class of work. We consider these charges as overhead and include under this heading such items as Surety Bond, Liability Insurance, Repairs to Equipment, Tools, Expense Accounts, etc. We also include under "Overhead" any labor that is not directly productive, such as salary of superintendent, work on equipment, etc.

We keep a check on the overhead by distributing daily to the columnar ledger mentioned farther on in this article the overhead items as taken from the general ledger, and add to this any unproductive labor as shown by the columnar book in which we record the labor costs.

Final Costs.—As explained under the heading of "Journal and Ledger" all entries are run through the general ledger, and a separate account is kept for each contract. While this general ledger account shows the total expenses and receipts, it does not tell at a glance just how much was spent for materials, how much for labor, sub-contract work, overhead, etc., and for this reason we use a special columnar ledger to supplement the general ledger for cost keeping purposes, in which we distribute each day from the regular ledger the expense of material, labor, sub-contract work, overhead, etc., and put this data in such form that each item of expense can be readily added up and totaled. This gives a daily record of the total expense on each contract, and shows just how much was spent for materials, how much for labor, sub-contract work, etc.

At the close of the contract, we make up a statement showing the actual unit costs and total costs on both labor and material and the percentage of expense and total expense of overhead as compared with the total expense of the contract.

Correspondence.

Current Correspondence.—To begin with, we make it a rule in handling current correspondence to treat of only one subject in each letter. If we wish to write to the same individual or firm on more than one subject, we split our correspondence up into as many letters as there are subjects, and instruct our foremen and superintendents to observe the same rule in their correspondence.

This takes a little time when writing the letters, but is a great help when it comes to filing the correspondence or finding it after it has been filed. We always show the subject of a letter in the upper left hand corner when writing the letter. Later on when the correspondence is transferred to the permanent file, we add a letter and number for ready reference.

As soon as the correspondence on a contract attains any bulk, we split the correspondence up into the different headings relating to that particular contract, such as, "Contract File," "Surety Bond," "Cement," "Gravel," etc., and make it a point to see that all correspondence with reference to the contract proper is kept on the "Contract File" and so on.

Permanent File.—We have divided our permanent file into the following branches: (1) Contracts, (2) Bids, (3) Dead Prospects, (4) General.

In this way we have all correspondence with reference to contracts in chronological order for each group or class. Our first contract is marked "Contract No. 1," the next contract "Contract No. 2." The same procedure is followed with the bids, dead prospects, and general subjects.

Wherever the correspondence on a finished contract is bulky, we split it into various subheadings, as explained under "Current Correspondence" and give each of these subheadings a letter of the alphabet following the contract number proper. For instance Contract No. 1, "Cement" might be indexed as "Contract No. 1—C."

Before changing the correspondence from the current to the permanent file, we place over the face of each file a manila postcard stock backer, similar to the one already on the back of the file of papers, and show on both front and back the subject matter and file number. This preserves the files in practically book form and precludes the possibility of papers becoming lost from their proper file. It puts the finished correspondence in neat and compact form for filing and in shape for ready reference.

Index to Permanent Files.—We use a loose leaf index book about 3x5½-in. for the purpose of recording the numbers of our files of correspondence. We have one division of this book for contracts, another for bids, still another for dead prospects, etc. Wherever a file has more than one heading, we list each subheading in this index.

From this index we make up in another section of the file index an alphabetical list of these same subjects, and to make reference still more ready, have in still another section of this loose-leaf book, classified lists in which we have listed under the proper title all files coming under the head of such subjects as Bridges, Pavements, Grading, Sewers, etc.

Conclusion.—This article gives a general outline of methods which have been worked out in actual practice for this company and have enabled one man to handle the office work in a way that has proved very satisfactory. It does not pretend to be the "last word" on office methods, as it could doubtless be improved upon, but in my opinion there are many contractors who might find at least some parts of it of value to them in the handling of their office work.

ROAD CONSTRUCTION COSTS AND CONDITIONS IN NORTH DAKOTA.

By Jay W. Bliss, State Engineer, Bismarck, North Dakota

The figures quoted have been furnished by the various county auditors. There are in use in North Dakota at the present time approximately 60,000 miles of various classes of roads, outside of the corporate limits of cities, towns and villages. Of this mileage it is estimated that approximately 26,000 miles are turnpiked and graded and in addition there are 1,100 miles of gravel roads and about 33,000 miles of ordinary ungraded roads. The average, then, for each county in the state is as follows: 20 miles of gravel roads; 500 miles of graded roads, and 640 miles of ungraded roads, or a total average of 1,160 miles of roads of all kinds.

The figures quoted as to the total mileage of roads in North Dakota represents work done since statehood. During this time the state has levied for roads and bridges approximately $9,169,670, and as nearly as can be estimated, within that time township funds have amounted to just about $12,000,000. We may say, then, that the roads that have thus far been built have cost to date over $21,000,000 (and be certain that the estimate is low rather than high), an amount equal to $350 per mile for the total estimated road mileage for the state of North Dakota. This amount includes bridges also.

During the season of 1915 there was spent for roads and bridges within the state, practically $2,400,000, or an average of $47,300 per county, while during 1916, 50 counties reporting will expend $2,639,859, exclusive of the automobile license refund, which during the year just closed amount to $71,434 and will not be less for the present year. Of this amount the counties have in their road funds $614,807, and in their bridge funds $549,581, while the townships will have available $1,475,471, the total amount equal to $4.07 for every man, woman and child enumerated within these 50 counties in the 1915 census. In other words, there will be spent for roads during the season of 1916, from all sources, an amount almost equal to the sum that is required to operate the entire machinery of the state government.

The state of North Dakota has been very adverse to progressive road legislation. The road work done in the past has not been efficiently done and there is no prospect of its being done any better under our existing plan. It is doubtful if a plant could be adopted which would be any more inefficient, and it does not seem that the state need be afraid of jumping from the frying pan into the fire in regard to road matters. All agree that our plan of work needs some remedy; apparently few agree as to what that remedy shall be, but I am convinced that the experience of North Dakota will not be different from that of other states, and that in the end it will be found that the best results will be obtained through centralizing the chief authority in road matters in county and state officers, in adopting and working toward some comprehensive plan, in dealing with the situation in every respect in a business like manner through the employment of expert road builders and road engineers, and the adoption and employment of every agency that makes for efficiency, to the end that for every dollar spent for road work we may hope to secure just as near a dollar's worth of work as may be, and that will be a vast improvement over a system which returns about fifty cents worth of work for every dollar spent.

TAMPER AND STRIKE BOARD FOR CONCRETE PAVEMENTS.[*]

If the strikeboard on roads and narrow pavements is used in the manner of a tamper, a firmer and more dense surface can be secured than from the shearing action of the ordinary board. For this reason handles should be provided by means of which the board can be worked with an up and down motion as it is drawn forward. In this connection there is offered a suggestion for a tamper and strikeboard used by G. E. Scott, contracting engineer of Norwalk, Ohio, with very satisfactory results on his work. The construction of the tamper and strikeboard is very simple, as shown in Fig. 1, the strikeboard being crowned slightly in excess of the finished road requirement, while the tamper is finished to the exact cross-section of the finished road. After the concrete is struck off in the usual way for 10 or 15 ft., the center being left slightly high, the tamper is used by two men, and moved forward a few inches at each application until the strikeboard is reached. In addition to giving the benefits of tamping for density, this brings the mortar to the face so that very little floating is necessary to secure a nicely finished road. Mr. Scott claims no originality for the device but believes it will prove as satisfactory to others as it has been to him.

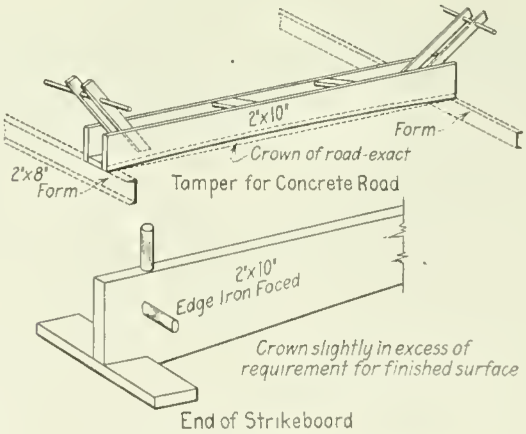


Fig. 1—Tamper and Strike Board for Concrete Pavements.

---

[*] Extract from report of Committee on Mixing and Placing Concrete presented at the National Conference on Concrete Road Building.

AN ANALYSIS OF THE ADVANTAGES OF MONOLITHIC BRICK PAVEMENT.*

By Maurice B. Greenough, Instructor in Highway Engineering, Case School of Applied Science, Cleveland, O.

There are two types of monolithic brick pavement construction. One type differs from the sand cushion type only in the addition of cement to the cushion course, producing a part which might more properly be called a cement mortar bedding course. A union is made with the finished surface of the concrete base, but it is only such union as may be obtained by bonding a thin layer of cement mortar to a prepared concrete surface, and to the bottoms of vitrified paving brick. Such is the method of construction applied in Baltimore, St. Louis, Cuyahoga County, and to a slight extent in Cleveland, during the past two years.

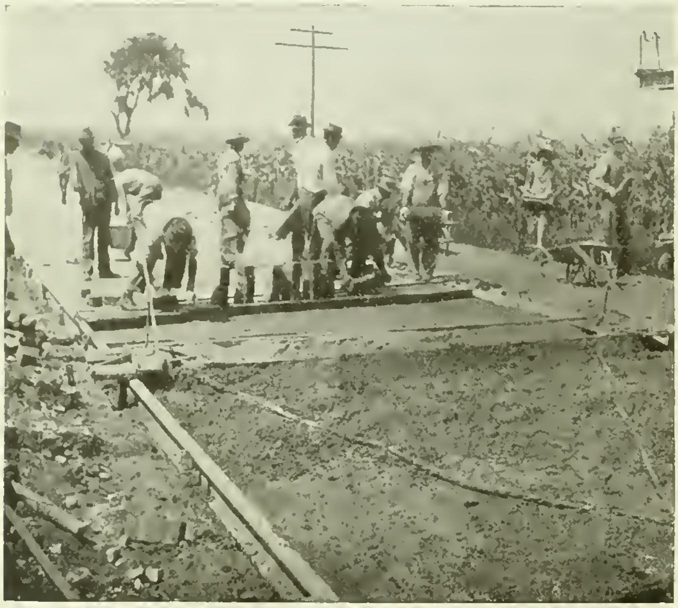


Fig. 1. Paris, Ill.; Middle Springfield Road, Laying Brick.

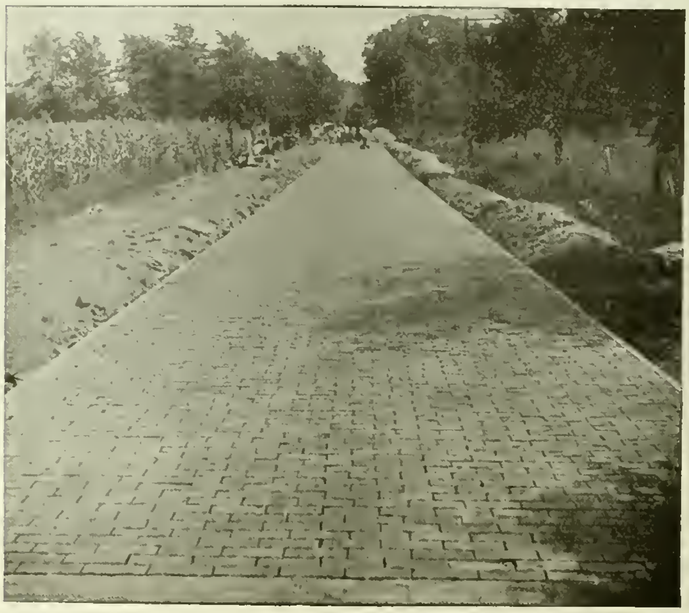


Fig. 2. Paris, Ill.; Middle Springfield Road Showing One Day's Work.

The other, as typified by the newly built roads at Paris, Ill., is a complete divorce from the old order. It represents the final step in consolidating the wearing surface and the foundation, so that both contribute their united strength to the structure. All semblance of a cusion or special bedding course is done away with, and the vitrified wearing surface is completely bonded to the green concrete base.

In analyzing the monolithic construction of brick pavements from the point of view of the three interests involved, the speaker uses the Paris type with the brick on the green concrete as the basis, in the belief that this is the ultimate aim of all monolithic construction.

First, From the Point of View of the Contractor.—Executives are agreed that the maximum efficiency in operation and organization obtain when the same men continue to exercise the same functions, in other words, specialization of effort. What holds for example in productive industry is equally applicable to the construction of pavements. Effective effort on the part of workmen building a road is obtained when each man becomes thoroughly familiar with the work which he has to perform and particularly if he has but one kind of work to do. The limit of effectiveness under specialized work is reached when lack of variety produces mental dullness and the attendant slowing up of the individual's effort. In road construction, however, the tendency to create dullness by specialized effort is offset by reasonable hours of labor, out-of-door environment, competition between other men performing other functions and proper supervision and oversight on the part of foremen and the contractors themselves. The complaint is often made by contractors that it is difficult to retain men for their construction which promises to be a credit to the man performing monolithic construction because of the simplicity of the operations involved and newcomers fit easily into the system.

Again, economy in materials, which decreases the amount of money which must be tied up during the prosecution of a contract, appeals strongly to the contractor. A type of construction which promises to be a credit to the man performing the work and one in which the hazards of unknown and unforeseen circumstances are reduced to a minimum commends itself strongly to the contractor.

All of these conditions are satisfied by the Paris type of monolithic construction. The entire force engaged in building the pavement is distributed over a distance of less than 75 ft. along the road, encouraging economy by making possible street supervision of all the work. The same men perform the same operations continually. For instance, certain men are always engaged in roughly striking off the concrete base and spading it about the forms; other are mixing the sand and cement luting course and keeping the template well filled; still others are constantly bringing in brick for the droppers and so on. Thus the entire operation proceeds at a uniform rate of speed throughout the day. There is no confusion or loss of time by changing duties. Economy in materials is effected by the elimination of the curbing or edging in country road construction. A saving is made in the amount of sand and cement required for the luting course over what would be required for a sand cement mortar bedding course, or even a plain sand cushion.

No time is lost in waiting for a concrete base to harden before brick laying may commence. In other words, there is no call for equipment to be brought on to the work until actual operations of constructing the pavement begin. Of course, the subgrade must be prepared, but except in unusual circumstances that may be going on simultaneously with the construction of the pavement only far enough ahead so that no time will be lost by breakdowns or other unforeseen delays in preparing the subgrade.

In the use of the special template which both strikes off and lutes the concrete foundation is found the critical point in construction. No make-shift template should be employed, it should be substantial and designed particularly for the work to be performed by it. The cost of the template is very small in proportion to the economy effected by its use. For the contractor who expects to build monolithic brick pavements, the cost of attaching a winding drum to the mixer for drawing the template ahead, is also relatively small and is entirely justified by the results secured.

From the View Point of the Engineer.—Every engineer hesitates to commit himself to new methods of construction, involving the expenditure of large sums of money without being certain of the ground upon which he stands, in order that his name shall not be lent to any plan which may later result in discredit to his professional judgment. This is a natural and justifiable attitude and it serves as a check on exploitation and over zealous attempts to improve methods which have been in use for many years. Unforunately we do not as yet have in highway engineering the criteria for predetermining pavement behavior under the diversified conditions of application which surround them, so that opinions upon the future performance of pavements must be based upon "a priori" reasoning, with past performances of accepted methods in view.

---

*Extracts from a paper read at the annual meeting of the Ohio Engineering Society.

The principal defects of the sand cushion type of brick pavements have been longitudinal cracks and surface depressions, caused by soft spots or shifting in the sand cushion, by imperfect grouting, or combinations of the two effects. The presence of moisture in the sand cushion which may freeze and expand during cold spells may also be a contributing factor in the formation of longitudinal cracks. One thing is certain, that the elimination of the sand cushion eliminates its hazards as well, and defects that develop must be attributed to some other source. So far, no longitudinal cracks have developed in monolithic pavements.

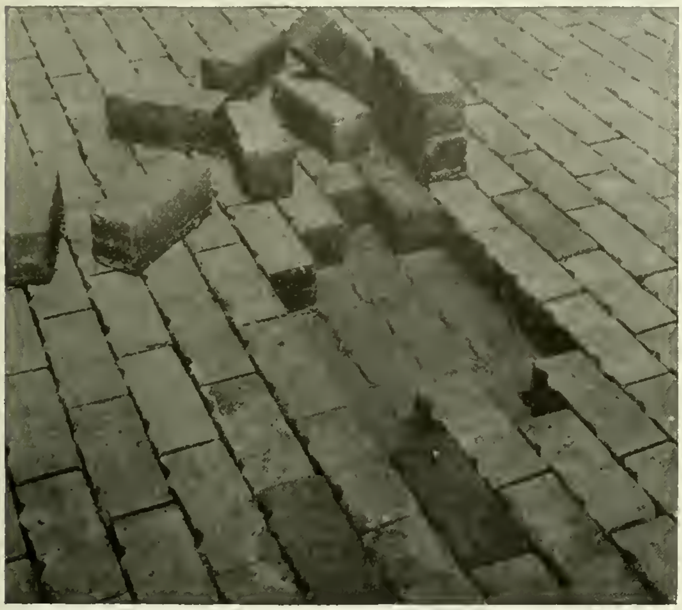


Fig. 3. Paris, Ill.; Middle Springfield Road Showing Brick Removed From Pavement.

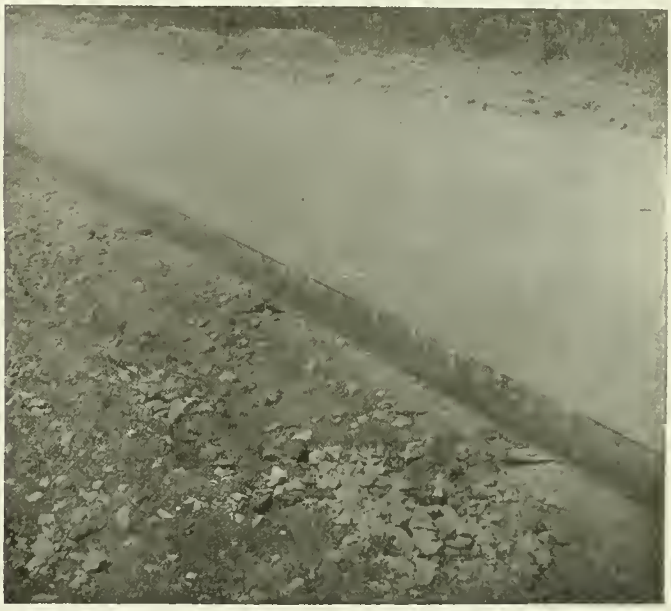


Fig. 4. Paris, Ill.; Middle Springfield Road Showing Brick Pavement Without Curbing.

The opinion of engineers has been expressed from time to time that they feared that at the end of five or six years, the bricks would become broken and battered on account of the anvil effect of the base when the surface is subjected to moving loads. In the absence of any specific data to prove or disprove this opinion, recourse must be made to a pavement constructed in Terre Haute, Ind., by this method, now twelve years old.

The pavement mentioned was laid at the side of Hulman & Co.'s building leading from the thoroughfare into the railroad yards. Throughout its life it has been subjected to heavy trucking. Originally it was provided with a stone curb at the side which for a time received the shock of loads coming diagonally upon the side of the pavement, since the entrance to the yards must be made by turning off the side and not directly off the end of the pavement.

A recent examination of the pavement by the speaker showed that the curb has been entirely disintegrated where vehicles come on to the pavement, and that excepting a slight cobbling of the exposed edge of the brick, the surface near the edge has received no injury. The entire surface of the pavement showed no defects. Such wear has occurred as might be normally attributed to heavily concentrated traffic. It may also be said that the bricks never received any rolling when they were laid.

We know that the ability of any structure to withstand the shock of suddenly applied loads depends upon the ability of the material to yield slightly and to store within itself internal energy equal to the amount of the external energy applied to produce the given state of distortion. This storage of internal energy is evidenced by the elastic recovery of the structure to its original position upon removal of the load. We commonly describe this function of a pavement as its resiliency. Just what the resiliency of a 4-in. brick surface firmly united to a 4-in. concrete base will be, is something to be determined by actual measurement.

A few measurements have been made to determine the resiliency of brick pavments by Mr. James E. Howard of the Interstate Commerce Commission, but beyond indicating a feasible line of investigation his results are not yet available for accurate computations. He measured resiliences of brick pavements under a load of one fourth a total vehicular weight of 5,540 lb., and found them to range between three ten-thousandths and one one-hundredth of an inch, but unfortunately his report does not describe the type of construction.

There is evidence to lead one to conclude that in some instances, the elastic limit of the surfacing has been exceeded in the stresses created by deflections, and of course, under this condition no elastic recovery could take place and permanent deformation resulted.

A careful study of monolithic pavement leads to the conclusion that they are inherently stronger, and better suited to withstand successive deflections without injury than is that type having the wearing surface and the foundation acting separately, the only connection between the two being dependent upon a layer of sand which may or may not establish a contact.

A proper conception of monolithic brick pavements is reached when they are considered in the light of a brick wearing plate, well adapted to resist attrition by traffic, combined with and supported by a layer of cheaper materials, possessing qualities which adapt it admirably as a foundation.

Third, From the Point of View of the Taxpayer.—The taxpayer's interest in improved roads lies not only in having a smooth and comfortable road over which to ride, but also in how much he must pay to secure such a road. His interest in monolithic construction is quickened by the knowledge that a type of construction for brick roads has been developed which promises to be equally and probably more satisfactory than the sand cushion type, and as has been indicated by work thus far performed, it is secured at a cheaper price. The speaker would not have his statements construed as a belief that monolithic brick construction will prove to be the method of constructing brick pavements. The art has not developed to the point at which it is safe to make positive statements regarding future performance. Actual performance under many different conditions is the ultimate criterion for judging the merit of any type of construction, but in the light of what is known of pavements and other structures of similar character, an opinion that an improvement has been made that will produce a pavement of superior quality to those built with a sand cushion seems at the present time to be justifiable.

ORGANIZATION IN KENTUCKY FOR SECOND YEAR OF STATE-AID ROAD CONSTRUCTION.

Contributed by Robert C. Terrell, Commissioner of Public Roads.

The Kentucky Highway Commission in 1915, the first year of state-aid construction, was hampered by a lack of funds which made it impossible to secure proper engineering supervision to look after the state-aid work throughout the 90 counties in which it was progressing. In 1916, however, arrangements are being made to secure the necessary funds, which will permit the state to be divided into 16 divisions with a supervising engineer in charge of each division, whose duties will be to visit each piece of construction work once a week and see that the work is properly carried on.

In addition to this supervising engineer, there will be on each job an inspector, who will devote all of his time to carrying out the specifications for the improvement of any particular piece of work. At least 100 counties in the state will be engaged in state-aid construction in 1916 and the work will doubtless range as it did in 1915 between the construction of ordinary earth roads on through the various phases of gravel, waterbound macadam, bituminous-bound macadam, bituminous concrete, concrete and brick construction.

Besides the field engineers, the Highway Commission will have a special force of bridge designers, office assistants, clerks and file keepers, who will materially assist in properly checking up the records. Plans will be made to keep an accurate cost system of each piece of construction and the conditions under which the work progresses, so that at the end of the year the Highway Commission will be in possession of absolute facts, which will be of assistance in awarding contracts the following year. Generally speaking, the entire plans are broader and more complete in detail than in previous years.

PROBLEM OF TRUNK LINE ROAD BRIDGE CONSTRUCTION IN CONNECTICUT.

Contributed by C. G. Nichols, Chief Clerk, State Highway Commission.

Without doubt, the most important road work confronting the state during 1916 is in connection with trunk line bridges. The Legislature of 1915 placed under the jurisdiction of the State Highway Department all bridges on trunk line highways having a span of 25 ft. or greater. An appropriation of $200,000 was made by the Legislature for the two years ending Sept. 20, 1917.

The law provides that when these bridges occur within a town the cost shall be borne equally by the state and the town. If between towns, one-half of the cost is paid by the towns in proportion to their grand list. If between counties, the counties are required to pay one-quarter each of the cost. Where a bridge is crossed by a line of trolley, the company owning such tracks is obliged to contribute one-third of the cost, the other two-thirds being borne by the state and towns or counties, as the case may be.

Considerable work already has been done under this law which became effective Aug. 1, 1915. At the present time a bridge 550 ft. long in the town of Westport is under construction. Plans also have been prepared for a bridge across the Housatonic River between Derby and Huntington. Several bridges of smaller proportions already have been completed.

Detailed reports on all bridges coming under the provisions of the law will be furnished to the department by the division engineers. These reports will also give information relative to possible changes in location to eliminate grade crossings, dangerous turns, etc.

While the appropriation is wholly inadequate to rebuild all of the bridges which have been found to be in need of attention, at the same time a definite start can be made in the work.

A law also was passed by the 1915 Legislature providing for the elimination of dangerous conditions on trunk line highways. Plans already have been made to eliminate the so-called "Death Trap" at Windsor, which work will be done during this season.

Although no definite appropriation was made for new work there are about $300,000 remaining from the old appropriations.

In addition to this, the Highway Commissioner has provided for a considerable amount of reconstruction of trunk line highways from the Trunk Line Repair Fund. Principal among the improvements already planned are intervals on the New Haven and Springfield Turnpike, Main St.; Main St., in the town of Naugatuck, which is on another important trunk line; Berlin St., on the Boston Post Road, and in the town of East Hartford on the principal trunk line running east and west through the state.

THE ROAD SITUATION AND STATE HIGHWAY DEPARTMENT PLANS IN ILLINOIS.

Contributed by Wm. W. Marr, Chief State Highway Engineer.

The Tice Road and Bridge Law provides for the construction of a connected system of permanent roads, built at the joint expense of the state and county. In counties of the first class 15 per cent of the entire road mileage of the county is to be improved with the help of the state; in counties of the second class 20 per cent, and in counties of the third class, 25 per cent.

Immediately after the passage of this law in 1913 the State Highway Department proceeded to outline a system of roads to be known as state-aid roads, to be improved in accordance with the provision of the new road law.

The county boards of the various counties were called upon to prepare maps of their counties showing the roads which they desired to designate as state-aid roads. These maps were then revised by the State Highway Commission so as to connect the various routes of the individual counties; the ultimate result being that there was developed a comprehensive plan for a system of permanent roads.

Sixteen thousand miles of roads are included in the designated state-aid routes out of a total state mileage of 96,000. It is conservatively estimated that these routes which are designated for state-aid improvement, while but 17 per cent of the total state mileage, carry fully 80 per cent of the traffic.

The Legislature in 1913 appropriated $1,100,000 for state-aid road work for the biennium of 1914-1915. The following session of the legislature in 1915 appropriated $2,000,000 for the biennium of 1916-7. These appropriations are allotted to the counties in the proportion of the road and bridge tax of the county, and must be met by like sums before they can be available to the county.

At the close of the last calendar year there had been constructed some 115 miles of state-aid roads, of which 90.5 miles are of concrete, 22.4 miles are brick, 1.2 miles are gravel, and 1 mile macadam. There were also 81 bridges included in the state-aid work up to this time. The total cost of this construction was $1,497,407, which was met equally by the state and counties.

Besides the state-aid road construction mentioned, the State Highway Department supervised the building of some 82 miles of township roads in the state in 1915. These roads were paid for by the townships by means of some special tax or by means of bonds. The State Highway Department assumed supervision of the construction; loaned to the township the road machinery owned by the state, and sometimes furnished a man to operate some of the machinery furnished. In many cases stone for some of these roads was furnished free to the township from the quarries at the two state penitentiaries.

This year a good many of the counties will use their state-aid allotments for the purpose of constructing oiled earth roads. There is a great deal of enthusiasm in the state just at present for this type of road, although there are many road experts who are quite skeptical as to the economic value of oil in this type of construction. The State Highway Commission, while it does not recommend an oiled earth road for heavy traffic, has consented to the use of the state-aid money for the purpose of oiling roads where the travel is comparatively light, provided that the road is properly graded and drained.

The State Highway Department estimates that there will be some 470 miles of state-aid roads constructed this year, divided as to type as follows:

	Miles.
Brick	11
Concrete	58
Gravel	22
Water bound macadam	5
Bitulithic macadam	6
Oiled earth	250
Plain earth	120

Of course these figures are but rough approximations, based on the type of road the county has selected, the amount of money available, and the estimated cost of construction.

In all earth road construction, whether oil is used or not, the road surface will be so graded and drained that any type of wearing surface may be placed thereon without additional expenditure for grading or draining.

The 1915 Legislature helped the good roads movement greatly when it amended the law so that the counties, if they so desire, can issue bonds to secure funds for the immediate improvement of their designated state-aid routes instead of building each year only the amount of road possible with the money allotted by the state, together with the like amount furnished by the county. In case a county issues bonds for the purpose of building state-aid roads, the law provides that the future allotments from the state can be used, if met with a similar amount by the county, in paying off these bonds.

The advantages of this method are manifold. It enables the people to pay for the road at the same time they are using it. It does not throw the burden of cost on the taxpayer of today for an improvement which will last for a score of years, and be a constant benefit to the taxpayer of the future. When a system of roads is constructed with money raised by a bond issue, those who get the benefits pay the costs, which is undoubtedly the way a public improvement should be paid for. Furthermore, if 50 miles or more of road are constructed in a county at one time, the unit cost will be much less than if the 50 miles or more of construction are spread out over a period of seven or eight years. It is always cheaper to buy in large quantities, and this law applies to roads as well as to any other commodity.

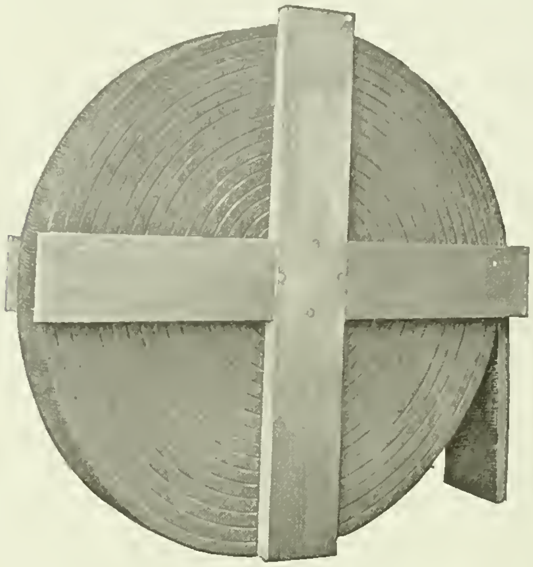
Vermilion County was the first county to issue bonds for the purpose of constructing their designated system of state-aid roads. They voted to issue bonds to the amount of $1,500,000 for the purpose of constructing 175 miles of permanent roads. Cook County has issued $2,000,000 in bonds for hard roads.

The enthusiasm for this plan of financing the construction of state-aid roads by bond issues is growing every day. The plan of getting all the roads improved at one time, without placing a heavy tax burden on the people, appeals very much to the counties. This is evidenced by the fact that at the present time there are some 30 counties in the state contemplating such bond issues, the total amount of which approximates $20,000,000—ten times the amount appropriated by the last Legislature for the purpose of road construction for a period of two years.

A NEW EXPANSION JOINT MATERIAL FOR PAVEMENTS.

(Contributed.)

A new material for the expansion joints of concrete, brick or block pavements is illustrated by the accompanying cut. It is a mastic which comes ready to lay, in ribbon form, in a variety of widths and thicknesses. It contains no felt or paper reinforcement. A new process known as the "fibre weld" process gives to the bituminous mastic the requisite cohesiveness to stand handling and storage in the ribbon form, without affecting the elasticity that is necessary for expansion requirements.



Barrett's New Fibre Weld Expansion Joint.

The new material seems to possess all the elasticity of a poured bituminous joint with all the advantages of easy handling. It is waterproof and weatherproof and is not injured by street acids or automobile oils. It does not become brittle with age or cold weather and does not soften or run in hot weather. Its chief advantage over the usual poured bituminous joint is the elimination of heating or pouring apparatus and a great reduction of the labor item, as it takes only a moment to unroll the joint and cut and put it in place.

The manufacturers are the Barrett Co., 383 Fourth Ave., New York, N. Y.

SOME NOTES ON SUBGRADE CONSTRUCTION FOR CONCRETE ROADS.*

By A. H. Gilliland, Civil Engineer, Indianola, Iowa.

The writer had charge of the placing and had prepared the specification for some 4.3 miles of 24-ft. concrete roadway for the city of Indianola, Iowa, in 1914. In this work the slab is 7 in. thick at the crown and 5 in. at the gutter with an average crown of .96 of the street width. On very flat sections there is an increase in the crown of a couple of inches, and on streets where there are steeper grades there is in some places a flat cross section. The concrete mix was 1 of Portland cement, 2½ of sand, and 3 parts of crushed rock or gravel. The sand was retained on a No. 30 sieve and passed a ¼-in. screen; the rock was graded from a ¼ screen to a 1.5-in. ring. All was clean screened material subject to test. If any change is made on this mixture it should be to reduce the sand content to 2 parts.

On part of this work the concrete was spread on the street just as it was left by the roller after the depressions made by the first rolling had been filled. On another part the crown section was loosened up some 2 to 4 in. down with the pick, and where there was surplus material it was cast out of the street before concreting. On other sections the grade was made by as thoroughly compacting the street as could be, leaving this hard compact surface approximately 2 in. below the top of the finished subgrade, and then bringing up to grade by placing on top of this rolled surface, fine pulverized top soil clear of vegetation, and finishing with a light two-horse grader for the rough leveling and then with straight-edge and shovel. There are one or two sections where there was a fill made on the top of an old traveled roadway, without first breaking up and pulverizing the old hard track. The fill being from zero to 18 in. Cary elastite expansion joint fillers were used in all of the work; ½-in. joints were placed on 26-ft. spacing at right angles to the center line of the street and along the gutter lines.

---

*Extract from paper read at the annual meeting of the Iowa Engineering Society.

The condition of this work as a whole is good, but in every case where a fill was made over an old traveled roadway, without first breaking it up and at most of the places where the centers were not loosened up where hauling was done over the street before placing the concrete, a longitudinal crack has developed. Only in a very few sections (that is 26-ft. sections) have any bad cracks occurred up to the present time. In no case has a crack occurred where the old roadway was broken up and pulverized before filling or at any place where the over-rolled center was loosened or where the cushion coat was applied. This subgrade was all kept well wet down just ahead of the concreting.

PROPOSED STANDARD FORM FOR REPORTING COSTS OF CONCRETE ROADS.*

This form is for the concrete pavement only. Cost of other items, such as grading, drainage, bridges, culverts, railings, etc., should be kept separately. In consideration of the items mentioned, a division should be made indicating those portions of the highway improvement which can be considered as permanent as differentiated from portions which will need renewal in the course of time. Such a distinction is necessary in order to work out any reasonable system of highway financing.

Name and Location of Road. ....
Length.. ....Width.. ... ...Thickness...............
Proportions of Mix............Number of Cubic Yards............

Per Cu. Yd.
1.* Labor:
On subgrade ....$......
On forms ....
Material to mixer..................... ......
Mixer to place........................ ......
Covering and cleaning................... ......

Total labor ....$......

2. Concrete Materials:
Cement, f. o. b.............................$......
Hauling ....
Storage ....
Loss sacks and waste................... ......
Sand, f. o. b............................ ......
Unloading ....
Hauling ....
Stone, f. o. b. or in bins................... ......
Unloading ....
Hauling ....

Total concrete materials.........................$......

Water:
Charge for ....$......
Piping ....
Pump ....
Labor, etc. ....

Total water ....$......

5. Plant and forms (interest and depreciation).............. ......
6. Reinforcement ....
7. Joints ....

Total cost concrete pavement..........................$......

WAGE SCALE.

Superintendent ....
Assistant Superintendent.......
Skilled labor....................
Common labor.................
Teams ....
Auto trucks....................
Length of working day.........

(Remarks on features of plant and materials which have special bearing on costs.)

*Includes supervision.

Proposed Standard Form for Reporting Costs of Concrete Roads.

It will be noted that the form calls for reporting the cost on a cubic yard and not on a square-yard basis. The latter has been a popular method of reporting city paving costs, but the former is probably now the prevailing practice on concrete road work. The cubic yard system has the disadvantage of preventing ready comparison with the costs of other types, but possesses other advantages which, in the committee's judgment, more than counter-balance the disadvantage. The square-yard basis, on the other hand, is not definite, for it neglects the thickness of pavement, making comparison between two concrete slabs of different thicknesses difficult. The cubic-yard basis is not open to this objection. The cubic-yard method of reporting gives repeated checks on the amount of stone and aggregate used and on the thickness of pavement itself.

---

*Extract from committee report to the National Conference on Concrete Road Building

EXPERIENCE WITH FULL METERAGE OF WATER SUPPLY AT MILES CITY, MONT.

Contributed by G. C. Pruett, City Engineer, Miles City, Mont.

The question, Does it pay to install water meters? confronts most water works officials in the west at the present time. More thought is being given to this subject than to any other by water works men west of the Mississippi River. The two chief arguments favoring meterage are:

1. By installing meters it is possible to forestall extensive improvements and extensions to the plant by reason of the reduced consumption following a general installation of meters, and,

2. It places all consumers on an equitable and fairly comparable basis.

No other business would consider for a moment the sale of its product except on a measured or unit basis, and the reason for not doing so in the case of water, where it is possible to meter, is certainly not sound.

Where water is pumped, as it is in most instances, or where it is piped through expensive conduits from costly supplies at some distant source, the cost of installing meters can generally be saved many times over on the cost of the original installation. Not only this, but the cost of maintenance will in most, and I believe in all, cases be less than the extra cost of maintenance and operation of the plant installed without considering the use of meters, not even taking into consideration the extra interest, depreciation, and reserve necessary for the larger and more expensive plant.

I have found in my experience at Miles City, Mont., first with a flat rate plant and later with one 100 per cent metered, that after getting the meters installed the general satisfaction among the customers is greater than it was on the flat rate basis.

Ours is a municipally owned plant, and by constantly keeping this matter before the community the citizens have come to regard the plant as belonging to them, and realize that all additional expense caused in operating the plant must necessarily be bourne by them. They have, therefore, welcomed the introduction of meters, for by doing so they know that every person using water is placed on the same equitable basis, and that the water hog will pay his proportionate share of the expense.

The matter of installing meters first came up in Miles City in 1911, but not having been sufficiently explained it met with some objection, and the ordinance authorizing the installation of meters was served with a referendum which required that it be submitted to a vote. The election was held in the early part of 1912, and carried by a good majority, in fact by a majority of 3 to 1.

The original intention under the ordinance was to begin metering gradually, getting first those using the greatest amount of water without a proportionately higher rate, and those who intentionally or carelessly wasted it, with a further provision that anyone else desiring it could have a meter installed by making application to the Superintendent. This was good for a starter, but after making a number of forced installations ("forced" installations being those on consumers known to be using a greater amount of water than they were paying for, and who naturally objected), and a few on application, I found pretty soon that applications began coming in so fast that I could not take care of them. At the end of two months not less than 75 per cent of our consumers had made application for meter service.

I might explain here that the meters were furnished and installed by the city without cost to the consumer except in cases requiring the rearranging of pipes, in which case the rearrangement was made by the city and charged to the consumer at cost. I have found in my experience both here and elsewhere, and am thoroughly convinced that this is the only practical and sensible way of handling this matter; i. e., that the utility furnish, install and maintain the meters, with of course proper regulations as to damage caused to the meter by neglect or carelessness on the part of the consumer. By this method the utility has proper control over the meter at all times, and is free to go ahead with necessary repairs or changes at any time without first having to go through a lot of preliminaries as would be the case with privately owned meters. I will add further that the utility's forces under proper organization can, and do, install meters a great deal cheaper than is the case where they are installed by the plumbers, and also that the installations can be made more uniform and in a more systematic manner. This in itself is a matter of considerable importance, especially with a municipally owned plant, inasmuch as a saving to the utility is a saving to the community.

Getting back to the original proposition, I have found, and I believe every other community will find, that installing meters is economically a step in the right direction, not only to the utility, but to the consumer as well. Meters admittedly will reduce the amount of water necessary to be furnished, and inasmuch as each gallon has a certain monetary value, a reduction in the number of these gallons will accordingly cause a reduction in the total cost of production. In other words, a plant of 5,000,000 gal. per day capacity will cost less to operate when producing only 3,000,000 gal. than it will if producing 5,000,000 gal.

With a meter schedule established on a proper basis; i. e., established so that the gross revenue will about equal the gross revenue from the flat rates, it will be found that a few will have to pay a great deal more than they would under the flat rate, but the majority will not. In our case, at Miles City, over 75 per cent of the consumers are getting off cheaper under the meters than they were formerly under the flat schedule, although the total gross revenue from the plant is substantially the same. The difference is paid by the 25 per cent who were formerly getting more than they were paying for. This same condition will be found in most communities.

The saving to the utility is caused by the reduced cost for power, piping systems, conduits, filtering equipment, pumping units, and general operating expense. I do not mean by this merely the reduced cost incident to the operation of the plant, but the cost of interest, depreciation, and reserve also, which would be required by the larger installation.

The question might then be asked, "Would it pay to install meters in a plant already installed and of ample capacity to supply present needs?" I would again say yes, provided the supply was pumped or treated and, generally speaking, in other cases also. It will be found with a pumped or treated supply that the reduced cost for power and chemicals will offset the extra cost for operating and maintaining the meters, and will also provide a reserve which will pay for the cost of the meters in from two to five years, taking it for granted that the rates are such as to produce substantially the same gross revenue.

On the other hand, if the supply is gravity and the quantity ample, the meter system is still the only equitable and reasonable basis on which to render bills and should be adopted. Each consumer is then paying for his own supply in proportion to the amount used while his neighbor is doing the same. Furthermore, where meters are installed one does not find the lack of a satisfactory pressure as is so often the case during the sprinkling hours with an unmetered system. This in itself should have some consideration, especially from the standpoint of fire protection.

Where the plant has reached or nearly reached its capacity, and enlargements are being considered, the most economical, and generally the most satisfactory solution of the problem will be found by the introduction of meters. Referring again to the plant at Miles City, at the time of installing meters we had about reached the capacity of our plant. To have provided a plant of ample capacity, with our prospective increase in population, and the rate of consumption to that time, would have required the expenditure of approximately $75,000. The cost for power (electricity), and chemicals at that time was approximately $7,000 per year. At the present time on the same basis of consumption the cost would be approximately $12,000 per year, but as a matter of fact is, with meters, only $6,000 per year. This is a saving of $6,000 per year, which added to the $6,000 per year interest and depreciation on the $75,000 extension, shows an apparent saving of $12,000 per year. I say apparent for the reason that the meters installed cost $12,500, interest and depreciation on which amounts to $1,937.50 per year. Add to this the extra cost for maintenance and operation, $1,100 per year, gives a total of $3,037.50 to be deducted from the apparent saving, leaving a balance of $8,962.50 on the credit side of the ledger—a very good showing on an investment of $12,500. Our plant is also of ample capacity for some years to come, and comparable in every way with what the plant would have been had the extensions been made and our flat rates continued.

A consideration of these facts will, I believe, convince the most skeptical that meters have been good for Miles City.

COMPARATIVE COSTS OF HAULING GRAVEL BY TEAM AND BY TRACTOR FOR ROAD WORK.*

By O. L. Kipp, District Engineer, Redwood County, Minnesota.

The data presented and the conclusions suggested are derived from the Gravel Checkers' records on five team hauling jobs totaling 22 miles of road gravelled and one tractor hauling job covering 3.6 miles of road gravelled; the gravel being placed at the rate of 15 cu. yd. per 100 ft. station on each job.

Team Hauling.—Gravel hauling by team is familiar to all and no description of outfit or method is necessary, other than the statement that ordinary dump planks were used and 1½ cu. yd. per load were hauled uniformly. The team wagons were loaded by hand shoveling. The number of shovelers in addition to the teamsters shoveling varied from none for a portion of the time on Job No. 1 to a maximum of two on all of the jobs.

The data obtained from the checkers together with percentages and averages derived therefrom have been compiled in the attached Table I, in which is shown for each job and each haul length on each job, the following data: Total loads hauled, average number of teams hauling, average number of loads per team day, load miles per team day, per cent of time dumping, per cent of time in pit, per cent of time required for loading at 12 minutes per load, minutes actually used in loading each load, per cent of time lost in loading, average number of teams at the pit, hauling cost per cubic yard, total loading and hauling cost, contract price, and the hauling cost per cubic yard mile for each length of haul.

From the same table we also find that providing the time of loading were reduced to 12 minutes per load the hauling cost per cubic yard mile would be as follows: 0 to ½-mile haul, 43 ct.; ½ to 1-mile haul, 27.8 ct.; 1 to 1½-mile, 23.8 ct.; 1½ to 2-mile haul, 22 ct.; 2-mile haul

---

*Paper read at the annual meeting of the Minnesota Engineers' and Surveyors' Society.

TABLE I.—GRAVEL HAULING COST DATA, REDWOOD COUNTY, MINNESOTA.

Length of haul	0-½ mile.			½-1 mile.			1-1½ miles.					1½-2 miles.				*	†	‡
Job No.	1	2	5	1	2	5	1	2	3	4	5	1	3	4	5	3	3	1
Total No. loads hauled	407	475	482	327	1571	364	606	525	898	44	746	312	873	434	198	337	267	714
Average No. teams hauling	7.2	5.2	4.5	9.6	7.0	9.0	6.5	7.6	7.0	6.0	8.7	6.4	7.5	5.2	4.6	8.0	7.2	18.7
Average No. loads per team day	12.1	14.0	9.45	9.75	11.67	7.35	7.0	9.1	7.55	7.33	6.0	5.4	6.93	6.73	5.35	4.6	4.0	3.9
Load miles per team day	4.24	4.62	2.83	7.31	8.75	5.51	8.75	11.38	9.44	9.16	7.50	9.45	12.13	11.78	9.36	10.35	11.00	11.51
Per cent time dumping (5 min. per load)	10.0	10.9	7.8	8.1	9.7	6.1	5.8	7.6	6.3	6.1	5.0	4.5	5.8	5.6	4.4	3.8	3.3	3.2
Average actual time in pit per load	30.6	25.0	46.0	26.6	16.5	46.7	30.7	11.0	24.4	24.5	45.0	36.0	11.5	14.2	37.2	36.0	35.1	30.9
Per cent actual time in pit per load	61.7	58.3	73.3	43.2	32.0	57.2	35.9	16.7	30.7	32.9	45.0	32.5	13.3	15.9	33.2	27.2	23.4	20.1
Per cent time required for loading at 12 min. per load	24.2	28.0	18.9	19.5	23.3	14.7	14.0	18.2	15.1	14.7	12.0	10.8	13.9	13.5	10.7	9.2	8.0	7.8
Per cent of time actually lost in pit	37.5	30.3	54.4	23.7	8.7	42.5	21.9	....	15.6	18.2	33.0	21.7	....	2.4	22.5	18.0	15.4	12.3
Average No. of teams at pit	4.5	3.0	3.3	4.1	2.2	5.1	2.3	1.3	2.2	2.0	3.9	2.0	1.0	0.8	1.5	2.2	1.7	3.8
Hauling cost per cu. yd. in cts	21.9	19.0	28.3	27.3	22.9	36.3	38.1	29.4	35.3	36.4	44.4	49.4	38.4	40.0	50.0	58.0	66.7	67.0
Total cost per cu. yd. in cts., loading and hauling	29.9	28.0	38.3	34.3	30.9	46.3	49.1	39.4	47.3	51.4	56.4	66.4	51.4	60.0	75.0	76.0	89.7	76.0
Contract price per cu. yd., cts	45.0	39.0	35.0	60.0	50.0	45.0	70.0	65.0	65.0	60.0	65.0	85.0	80.0	75.0	80.0	107.5	122.5	109.0
Spreading cost per cu. yd., cts	2.00	2.25	3.75	1.75	2.00	2.50	3.75	2.50	3.00	3.75	3.00	5.00	3.25	5.00	6.25	4.50	5.75	2.25
Hauling cost per cu. yd. mile, cts. (actual)	73.0	57.6	94.3	36.4	30.5	48.4	30.5	23.5	28.2	29.1	35.5	28.2	22.0	22.8	28.5	25.8	24.3	22.7
Hauling cost per cu. yd. mile., cts. (with 12 min. for loading)	43.0	43.0	43.0	27.8	27.8	27.8	23.8	23.5	23.8	23.8	23.8	22.0	22.0	22.0	22.0	21.2	20.6	21.2
Hauling cost per cu. yd. mile, cts. (with 6 min. for loading)	....	....	34.1	24.5	....	....	21.7	....	....	....	....	....	....	....	....	....	....	....
Hauling cost per cu. yd., cts. (with 12 min. for loading)	....	13.5	....	....	20.5	....	29.8	....	....	....	....	....	38.5	....	....	....	....	....
Hauling cost per cu. yd., cts. (with 6 min. for loading)	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....

Above figures based on 25 cts. per hour for man alone and 40 cts. per hour for man and team.
*2-2½ miles. †2½-3 miles. ‡2.95 miles.

and over, 21.5 ct. If the loading time could be reduced to 6 minutes per load the hauling cost per cubic yard mile would be further reduced as follows: 0 to ½-mile haul, 34.1 ct.; ½ to 1-mile, 24.5 ct.; 1 to 1½-mile, 21.7 ct.; and above that, 21.5 ct. per cubic yard mile.

Also, on a 12-minute loading basis the cost per yard for the hauls would be as follows: 0 to ½-mile, 13.5 ct.; ½ to 1-mile, 20.5 ct.; 1 to 1½-mile, 29.8 ct.; 1½ to 2-mile, 38.5 ct.; (2 plus X) miles, 44 ct. plus 22 miles.

The data in the table warrants these conclusions for we find in Job No. 2 on the ½ to 1-mile haul the cost was 22.9 ct. with an 8.7 per cent loss of time at the pit; on the 1 to 1½-mile haul the cost was 29.4 ct., as compared with 29.8 ct. as estimated, while on the 1½ to 2-mile haul of Job No. 3 the cost was 38.4, as compared with the estimated cost of 38.5 ct. and on a 2.95-mile haul the cost was 67 ct., with a 12.3 per cent loss of time as compared with the estimated cost of 65 ct.

It would thus appear that efficiency in team hauling and consequent low cost is largely dependent upon and might easily be secured by obtaining the maximum efficiency in loading. This problem is by no means as easy as that of the hauling for many varying conditions are encountered. The total loading and hauling cost on the various jobs was figured to provide for the shovelers actually employed and $5 per day additional for the general superintendence of a foreman or the contractor. The resulting loading costs varying from 7 ct. to 25 ct. per yard, the lower figures being too low on account of the teamsters acting as shovelers while waiting to get into the pit and the highest figures being boosted on account of an excessive amount of frost and firewater, and poor supervision. The lowest job average for loading was secured on Job No. 2, it being 9 ct. per yard. Favorable pit conditions were a large factor in producing this low figure. It would appear that for average Redwood County pits 10 to 15 ct. per cubic yard should cover the item of loading by hand. Whether or not some mechanical loader would be able to reduce this item I am unable to state.

Tractor Hauling.—The failure successfully to solve this mechanical loading problem contributed in a large measure towards increasing the figures I am able to present on gravel hauling by tractor.

The tractor hauling outfit used in Redwood County consisted of a 30-60 Holt Caterpillar Gas Tractor and a train of 7 Troy 3½-yd. reversible spreader wagons, a 50-yd. storage bin and a belt conveyor loader.

Difficulties were encountered from the very start. Considerable time was consumed in erecting the storage bin and loader. When the first train was finally loaded ready to start it was found that the tractor would not pull more than two cars over a short sharp pitch at the railway crossing on the most direct route. After some investigation and experimenting it was found that four cars could be hauled across private fields to the top of a short pitch about ¾ of a mile from the pit and that by doubling back for the remaining three cars a train of 5 cars could be made up and hauled the remaining distance of 2¼ miles. A total of 1,365 cu. yd. was hauled in this way over an average haul of 3 miles or a total of 4.125 cu. yd. miles at the average rate of 129 cu. yd. miles per day, which on a basis of $20 per day to cover the cost of operation, interest and depreciation, was at the rate of 15.4 ct. per cubic yard mile for the hauling.

From the next pit they hauled a total of 1,584 cu. yd. onto a stretch from 1 to 3.6 miles distant, making a total of 3,422 cu. yd. miles. There were no grades greater than 2 per cent on this stretch and they made an average of 142 cu. yd. miles per day on this work, the cost being 14.1 ct. per cubic yard mile. In several days they were able to make as high as 216 cu. yd. miles, which would be at the rate of 9.2 ct. per cubic yard mile.

From the foregoing it would appear that the cost of hauling by tractor was considerably less than by teams. The advantage in favor of the tractor would have been even greater, in my opinion, had there been more power available. A 40-80 tractor would have made a much better showing. Another factor cutting down the capacity of the train was the inability of the loading equipment to supply gravel fast enough. With ample power to pull six cars and a train load of gravel always ready when the train arrived at the pit there is no doubt that the record of 9.2 ct. per cubic yard mile made on a few days could have been maintained throughout the job.

However, in tractor hauling it is essential, as I have suggested, to have a bin full of gravel ready to dump into the cars quickly when the train arrives at the pit, for the outfit cannot make any money while waiting to be loaded. A bin of from 25 to 30 cu. yd. capacity must be provided. The bin must be portable, easily transported from pit to pit. This portable feature is essential for the loading apparatus also. Unfortunately my experience in this instance does not prepare me to tell you what equipment is practical, but I can tell you that a belt conveyor and a non-portable bin is not practical for I've seen them tried and the cost of tearing down, moving and re-erecting the bin amounted to fully 10 ct. per yard of gravel handled. The belt conveyor may be successful on a level grade or a very slight incline, but when it comes to raising the gravel about 30 ft. vertically you have gone beyond the practical range of a belt conveyor. I have no definite data as to the cost of loading with this apparatus, but as nearly as I can estimate it was between 25 and 30 ct. per yard, which together with the cost of moving the bin makes a total loading cost of 35 to 40 ct. per yard.

It would seem with the proper equipment the total loading cost should not exceed 10 ct. per cubic yard. If this is possible the comparison between tractor and team hauling is very much in favor of the tractor.

Besides the cost there are other features in favor of the tractor hauling which I wish to point out briefly. First: By applying the gravel in two courses with a tractor you get your gravel rolled without additional cost and the road is ready for travel as soon as the gravel is applied instead of a month or more later as with teams. Second.: By loading into a bin; thence to wagons and thence to the road you obtain an efficient mix of the materials so that instead of having one load with good gravel with a fair amount of binder followed by a load of sand with no binder and the resulting hard bump and chuck hole a few weeks later you have a gravel of uniform consistency which does not tend to develop waves or chuck holes.

AN UNUSUAL APPLICATION OF THE RATTLER TEST FOR PAVING BRICKS.

Contributed by F. L. Roman, Testing Engineer, Illinois State Highway Department, Springfield, Ill.

The following work was undertaken in connection with an investigation, suggested by Mr. Wm. W. Marr, Chief State Highway Engineer, of the cause of failure of a brick pavement on one of the main streets in Chicago. The bricks entering in this pavement had been tested in the old type of rattler before laying, and appeared at the time to be entirely satisfactory. A few years after construction the bricks had been worn so badly, however, that the pavement had become a complete failure, and when this work was undertaken the blocks from the center of the pavement were worn in many cases through more than half their original thickness. A number of samples of the bricks which had been subjected to practically no traffic were taken from the sides of the pavement, and were tested both in the old and new type of rattler. The average loss of these blocks in the old type of rattler (using angular shots) varied from 10 to 15 per cent, while in the new type of rattler (using spherical shots) recommended by the National Paving Brick Manufacturer's Association, the loss varied from 15 to 25 per cent. The average specific gravity of the bricks tested was about 2.27 and their average absorption in 48 hours 2.1 per cent. The gravity of the blocks was somewhat lower than usual but the bricks appeared to be dense as shown by the absorption.

Rattler tests on partly worn blocks show abnormally high losses not only in per cent, but in actual weight. It appeared, therefore, that the blocks had a fairly hard exterior but a rather soft interior. To determine if this assumption was true, ten of these blocks were rattled repeatedly through 900 revolutions and the per cent loss determined at the end of every 900 revolutions. Ten blocks representing 5 brands of paving bricks were tested in a similar manner and the two sets of bricks were rattled alternatively. Each brick was marked in such a way that it could be identified during the test. When a brick broke in the rattler the weighing of the pieces was not undertaken, but they were retained in the charge. The tests were performed in a standard paving brick rattler (as recommended by the National Paving Brick Manufacturer's Association) rotated at the rate of 30 R. P. M. The results are shown in Tables I and II and also by the curves in Figs. 1 and 2.

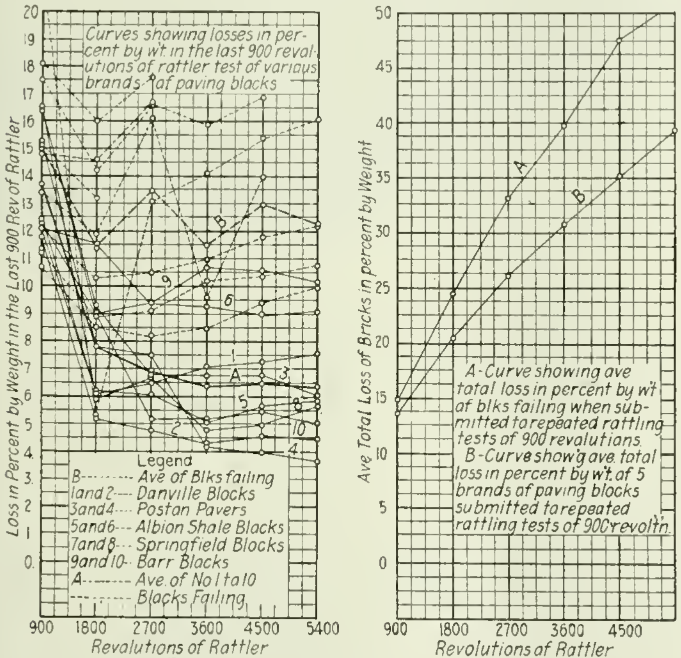


Fig 1

Fig 2

Figs. 1 and 2.—Curves of Rattler Tests of Paving Brick.

TABLE I.—SHOWING LOSSES IN PER CENT BY WEIGHT OF BRICKS IN LAST 900 REVOLUTIONS.

Revolutions of rattler.......	900	1,800	2,700	3,600	4,500	5,400
Brick No. 1, per cent loss....	12.1	10.3	10.5	11.0	11.8	12.2
Brick No. 2, per cent loss....	10.7	8.5	8.2	8.5	9.4	10.0
Brick No. 3, per cent loss....	21.0	5.3	13.1	14.1	15.4	16.1
Brick No. 4, per cent loss....	14.8	14.6	16.7	....	....	....
Brick No. 5, per cent loss....	11.2	8.9	9.1	10.2	10.4	10.8
Brick No. 6, per cent loss....	18.1	16.0	17.6	....	....	....
Brick No. 7, per cent loss....	17.5	14.2	16.6	15.9	16.9	....
Brick No. 8, per cent loss....	15.1	13.2	....	....	....	....
Brick No. 9, per cent loss....	13.4	11.9	16.1	9.6	14.0	....
Brick No. 10, per cent loss...	16.5	....	....	....	....	....
Average per cent loss....	15.0	11.4	13.5	11.5	13.0	12.3
Brick No. 1d, per cent loss..	12.4	6.1	6.5	7.1	7.3	7.6
Brick No. 2d, per cent loss..	11.8	5.2	4.8	4.3	4.6	4.5
Brick No. 3p, per cent loss..	16.4	9.3	6.8	6.8	6.8	6.1
Brick No. 4p, per cent loss..	15.2	7.8	7.5	4.2	4.0	3.7
Brick No. 5a, per cent loss..	12.1	6.2	6.1	5.1	5.7	5.9
Brick No. 6a, per cent loss..	12.1	11.6	9.3	9.3	9.0	9.1
Brick No. 7s, per cent loss..	11.3	....	....	....	....	....
Brick No. 8s, per cent loss..	16.5	5.9	6.7	4.8	5.0	5.7
Brick No. 9b, per cent loss..	16.5	9.0	9.4	10.7	10.6	10.2
Brick No. 10b, per cent loss.	12.3	9.0	5.2	5.2	5.5	5.1
Average per cent loss....	13.7	7.8	6.9	6.4	6.5	6.4

Note.—1d and 2d, Danville blocks; 3p and 4p, Poston pavers; 5a and 6a, Albion shale blocks; 7s and 8s, Springfield blocks; 9b and 10b, Barr blocks.

TABLE II.—SHOWING TOTAL LOSSES IN PER CENT BY WEIGHT OF BRICKS.

Revolutions of rattler.......	900	1,800	2,700	3,600	4,500	5,400
Brick No. 1, per cent loss....	12.1	21.1	29.4	37.2	44.6	51.4
Brick No. 2, per cent loss....	10.7	18.3	25.0	31.4	37.9	44.1
Brick No. 3, per cent loss....	21.0	25.2	35.1	44.2	52.8	60.4
Brick No. 4, per cent loss....	14.8	27.3	39.4	....	....	....
Brick No. 5, per cent loss....	11.2	19.0	26.5	33.9	40.8	47.2
Brick No. 6, per cent loss....	18.1	31.3	43.4	....	....	....
Brick No. 7, per cent loss....	17.5	29.5	41.0	50.4	58.8	....
Brick No. 8, per cent loss....	15.1	26.3	....	....	....	....
Brick No. 9, per cent loss....	13.4	23.4	35.7	41.9	50.0	....
Brick No. 10, per cent loss..	16.5	....	....	....	....	....
Average per cent loss....	15.0	24.6	33.2	39.8	47.5	50.8
Brick No. 1d, per cent loss..	12.4	17.8	23.1	28.5	33.7	38.7
Brick No. 2d, per cent loss..	11.8	16.4	20.5	24.0	27.5	30.7
Brick No. 3p, per cent loss..	16.4	24.2	29.4	34.2	38.8	42.5
Brick No. 4p, per cent loss..	15.2	21.8	27.6	30.7	33.2	35.9
Brick No. 5a, per cent loss..	12.1	17.6	22.6	26.6	30.8	34.8
Brick No. 6a, per cent loss..	12.1	22.2	29.7	36.1	41.9	47.2
Brick No. 7s, per cent loss..	11.3	....	....	....	....	....
Brick No. 8s, per cent loss..	16.5	21.4	26.7	30.3	33.7	37.5
Brick No. 9b, per cent loss..	16.5	24.1	31.2	38.6	45.1	50.7
Brick No. 10b, per cent loss.	12.3	20.2	24.7	28.3	32.2	35.7
Average per cent........	13.7	20.6	26.2	30.8	31.2	39.3

Note.—1d and 2d, Danville blocks; 3p and 4p, Poston pavers; 5a and 6a, Albion shale blocks; 7s and 8s, Springfield blocks; 9b and 10b, Barr blocks.

SETTLING THE PRINCETON, IND., WATER RATE CASE.

The Indiana Public Service Commission announced its decision in the rate case between the city of Princeton and the Princeton Water and Lighting Co. on March 27. The original case was filed Nov. 1, 1913, by the city of Princeton, and charged that the service by the company was inadequate and inefficient and that excessive and unreasonable rates were charged.

The commission fixed the value of the assets of the plant, both tangible and intangible, at $190,000. The actual physical value of the plant was fixed at $165,000, to which was added $5,000 for real estate values, making the total physical valuation $170,000. In addition to this sum the commission allowed $20,000 for working capital, material and supplies.

The commission also determined that 1 per cent of the value of the physical properties should be set aside for a depreciation fund. This per cent will be based on $165,000. No value was allowed by the commission on account of paving over mains, for the reason that the evidence shows conclusively that no pavement was cut by the defendant company in laying its mains."

In deciding on the rates, the commission decided that 7 per cent return on "the total value of the property of this utility" was a reasonable earning and allowed that amount. Basing its estimates on the past and present operating expenses of the company the commission in fixing its rates made provision for the following items:

Operating expenses and taxes	$20,050.00
Depreciation	1,650.00
Seven per cent on investment	13,300.00

With these figures as bases, the commission's schedule of rates was as follows:

For fire hydrants, $50 a year a hydrant. Commercial and domestic meter rates: For first 25,000 gallons, 25c a thousand gallons; for next 25,000 gallons, 20c a thousand gallons; for next 25,000 gallons, 15c a thousand gallons; for next 25,000 gallons, 10c a thousand gallons; for next 100,000 gallons, 8c a thousand gallons; for next 300,000 gallons, 7½c a thousand gallons; for next 500,000 gallons, 7c a thousand gallons; for next 4,000,000 gallons, 6½c a thousand gallons; for all over 5,000,000 gallons, 6c a thousand gallons.

For water furnished for steaming purposes, 6 ct. per 1,000 gal. for all water used by one customer, with a minimum monthly charge of $300 a month.

On metered service, the following are the minimum monthly charges: One-half, three-eights and three-fourths-inch meters, 75 cts. a month; 1-in. meter, $1 a month; 2-in. meter, $2.50 a month; 3-in. meter, $5 a month; 4-in. meter, $10 a month; 6-in. meter or larger, $20.

For private fire protection the minimum monthly charge shall be 1½ times the above charges.

The commission fixed the flat rate for water supply service "until changed or withdrawn by the metering of such service," at $7 a year for domestic rate, with the following explanation: "This rate is for private families in dwelling houses only, and for one family only. This rate must be paid by each domestic consumer, and does not include any outside connection. Consumers with an outside opening, and without inside connections, are entitled to this rate. Each other connection is in addition to this domestic rate."

The remainder of the flat rate schedule provided for a charge of $4 for each additional family, without inside connection; $5 for kitchen sink, $3.50 for bath, $3.50 for closets, $3 for heating boilers, $3 for one horse owned by a family and $2 for each additional horse, $2 for one cow, $6 for sprinkling privileges, "where water is taken on the premises, 50 ft. front or less, for portion of year when sprinkling is desired," and 10 ct. for each additional foot, $10 for one faucet in stores and $5 for each additional opening, $7 for one faucet in churches and $5 for each additional opening, 10 cts. for each 1,000 brick in building construction use, and many other items.

The commission ordered that in installing services after the order takes effect that the water company shall pay the cost of installing the services to the property line, the customer shall pay accruing charges thereafter. The company is given the right, as is the customer, to install a meter, in either case at the company's expense, whenever a change from a flat rate to a meter rate is desired.

The new rates become effective April 1. Under orders from the commission, the company some time ago put in a new filter and is now providing a fine quality of water.

CHICAGO ENGINEERS AND CONTRACTORS FORMING JOINT COMMITTEE ON MILITARY ENGINEERING.

A group of prominent engineers and contractors of Chicago has formed a joint committee on military engineering. The purposes of the committe are to further military preparedness among engineers, contractors and their associates by the following means:

1. Courses of lectures.
2. Assigned reading.
3. Study and practical instructions on military engineering.
4. To urge engineers to qualify as officers in the National Reserve Corps of Civilian Engineers.
5. To urge enlistment and support for the engineer troops of the National Guard and such other organizations as the Government may create.
6. To urge instruction in military engineering in training camps and attendance in them of those qualified.
7. By such means as from time to time may be deemed advisable.

The program as outlined so far extends from April 20 to July 25 and includes a course of lectures by several I. N. G. officers as well as several representatives from the engineering corps of the U. S. Army. This program includes field practice and inspection of equipment as well as correspondence courses and lectures.

Engineers, contractors and their associates are invited to join this committee. Correspondence should be addressed to the Secretary, Robt. F. Hall, 111 West Washington St., Chicago.

The directors and officers are: Wharton Clay, Chairman; Robt. W. Hunt, Vice-Chairman; Robt. F. Hall, Secretary-Treasurer; Bion J. Arnold, W. W. DeBerard, J. de M. Macomb, H. S. Baker, Robt. R. Randolph, Vernon C. Ward, Jr.

COSTS OF CONCRETE ROADS IN THE UNITED STATES IN 1914.*

Figures gathered in 1914 by the concrete road inspection forces of the Association of American Portland Cement Manufacturers give the following costs for concrete roads. As thickness of concrete is not given, no direct comparison is possible. The costs for the most part are low and should be used with caution.

TABLE SHOWING CONCRETE ROAD COSTS REPORTED BY ASSOCIATION OF AMERICAN PORTLAND CEMENT MANUFACTURERS.

State.	Name of town or road.	Square yards.	Labor.	Teaming.	Mechanical equipment.	Material.	Miscellaneous.	Total cost per sq. yd.
Fla.	Fort Tampa City	1,882	.105	.004	.004	.878	.016	1.047
Ill.	Belleville (av'ge for 2 weeks)	.....	.153	.050	....	.9972	.001	1.2012
Ill.	DeKalb	3,642	.2773	.1009	.033	.5284	.0162	.9558
Ill.	Morrison	6,500	.1203	*...	....	.8993	.0043	1.024
Ill.	Moline	2,889	.1333	.243	....	.5533	.005	.9346
Ind.	Anderson & Middletown	2,316	.1125	*...	.0309	.7336	....	.8771
Ind.	Woods-Henderson	638	.1072	.144	.0040	.880	....	1.135
Ind.	Seymour	4,110	.080	.160	.0010	.696	.005	.942
Iowa	Bloomfield	641	.247	.044	.008	.908	.008	1.215
Iowa	Indianola	9,716	.1595	.0353	.0141	.829	.0015	1.0394
Iowa	Cedar Rapids	2,027	.1871	.111	.032	.869	.042	1.2421
Iowa	Eagle Grove	3,033	.171	.122	.009	.954	.009	1,265
Iowa	Nevada	2,047	.1893	.0517	.021	.860	....	1.122
Iowa	Clarinda	1,399	.274	.057	.065	.834	.046	1,276
Kan.	Bassett	7,310	.3499	....	.0278	.910	.006	1,2837
Ky.	Bardstown Rd.	1,180	.180	.214	.020	.476	.029	.919
Md.	District Line, Seat Pleasant	1,219	.136	.138	.076	.809	.633	1,192
Md.	Fredericktown	2,453	.103	.141	.050	.692	.049	1.035
Md.	Galena-Georgetown	1,504	.102	.108	.069	.675	.069	1.023
Mass.	Northridge	360	.218	.098	.046	.653	....	1.015
Mass.	North Andover	420	.177	.1307	.030	.663	....	1.00
Mass.	Taunton	360	.191	.084	.041	.510	....	.826
Mich.	Kawkawlin Rd.	1,347	.168	.006	.016	.699	.016	.906
Mich.	Flint, N. Saginaw St.	1,056	.459	.047	....	.760	.037	1,303
Minn.	Minneapolis	3,448	.130	.1304	.2999	.5505	....	1.1108
Miss.	Tupelo	1,504	.102	.108	.069	.675	.069	1.023
Mo.	Boonville	388	.084	.086	.0025	.563	.003	.7385
Mo.	St. Louis	7.620	.2868	.0451	....	.903	.0295	1,2644
Mo.	St. Louis, Gravois Rd.	5,278	.256	....	.2571	.740	.0075	1,2606
N. H.	Nassau, Bridge St.	575	.1258	.0912	.0323	.907	....	1.1563
N. J.	Red Bank, Mechanics St.	1,172	.244	.090	.013	1.108	....	1.455
N. J.	Union Co., Linden Twp.	2,611	.122	.080	.029	.805	....	1.036
Ohio	Rockport	1,283	.162	.092	.151	.648	....	1.053
Ohio	Madison Twp. Road	986	.250	.225	.055	.456	.011	.997
Ohio	Addy Pike	1,657	.091	....	.067	.882	....	1.040
Ohio	Ironton, Law Alley	498	.209	.049	.060	.652	....	.970
Penn.	Nicholson Borough	1,942	.300	.078	.033	.715	....	1.081
Penn.	Nazareth, Main St.	484	.222	.029	.012	.623	.055	.941
Texas	Robinson Rd.	2,026	.446	.220	.010	.454	.024	1.154
W. Va.	West Union	.....	.098	....	.074	.853	....	1.025
Wis.	Racine	4,015	.1665	.088	.1059	.829	.012	1.2014
Wis.	Eau Claire	2,031	.2168	.0474	.0224	.5611	.0186	.8663
Wis.	Superior	1,520	.1602	....	.0005	.8256	....	.9863
Canada	Ontario, St. Thomas, York St.	172	.2714	.1124	.0952	.8127	.0206	1.3123
Canada	Stratford, Paterson Ave.	189	.1735	.0563	.0460	.8611	.0079	1.1448
Canada	Chatham	399	.1276	.0427	.032	1.0317	.002	1.2360
Canada	Jarvis	296	.2121	.1076	.010	.713	.013	1.0557
Canada	Ontario, Jarvis	347	.147	.068	.013	.851	....	1.079
Canada	St. Thomas	186	.1870	.114	.0396	.7745	.001	1.1161

*Teaming in Material Column.

PUTTING MACADAM ROADS IN THE PERMANENT CLASS.

Contributed by Daniel T. Pierce, Philadelphia, Pa.

Several factors have combined of late to bring into prominence the resurfacing of macadam and stone roads by the penetration and mixed methods. Macadam and kindred types of roads are common in every locality in which stone suitable for road purposes is found, and their mileage is very extensive.

---

*Extract from committee report to the National Conference on Concrete Road Building.

The resurfacing method is a subject of interest for sundry reasons. From the viewpoint of the engineer, the process is simple compared with that attending the construction of many types of highways. Where stone or macadam roads have been subjected to traffic for a period of years, they provide excellent foundations. Where funds are not available for the construction of entirely new and more costly roads, the low cost of the resurfaced road as it pertains to both construction and maintenance also appeals to the taxpayer. In many counties and townships road funds are entirely inadequate to meet extended highway improvement, while traffic conditions have become acute owing to the advanced deterioration of stone roads. Taxpayers so situated are disposed to entertain a proposition to put existing stone roads in the permanent class when it can be done at a cost not exceeding the prices they are accustomed to pay for ordinary stone highways—especially when the improvement comprehends the elimination of the mud and dust nuisance and the further advantage of greatly reduced maintenance.

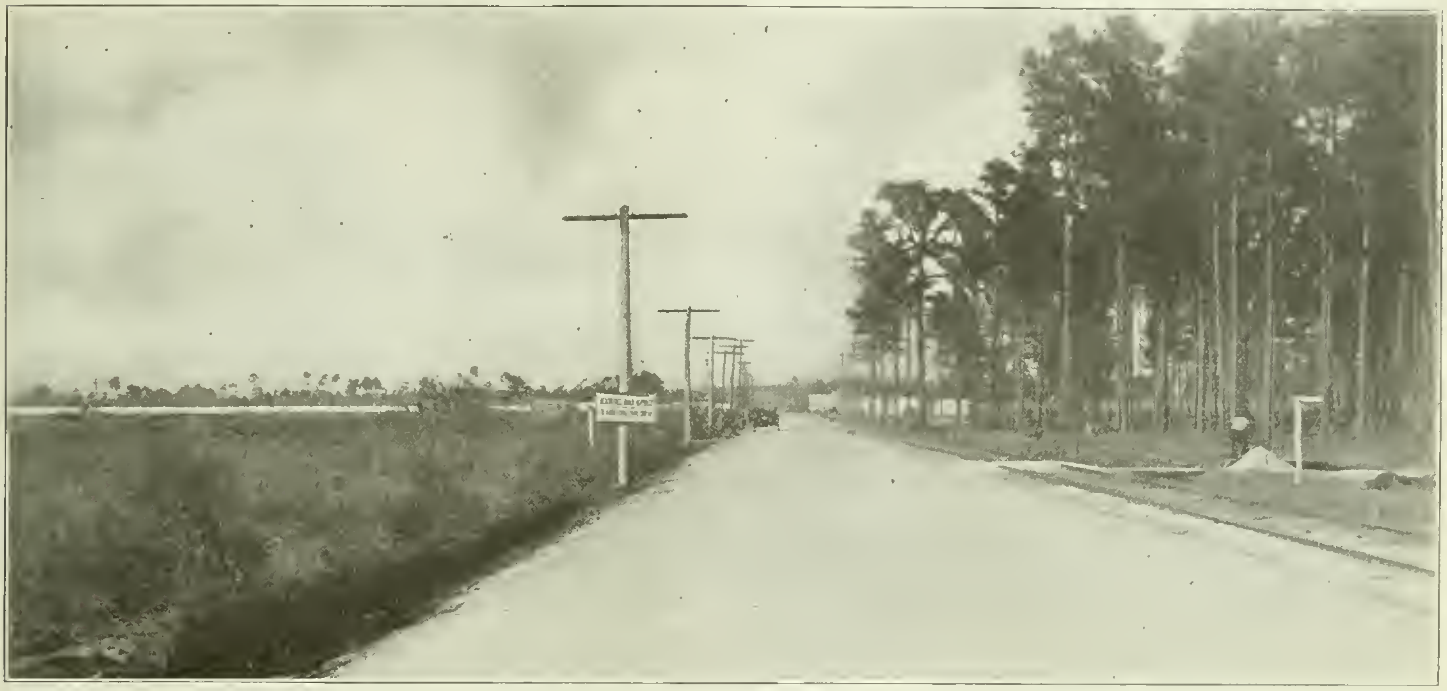


Fig. 1. Asphalt Macadam on Old Shell Base Built by Penetration Method in 1911 at Jacksonville, Fla.

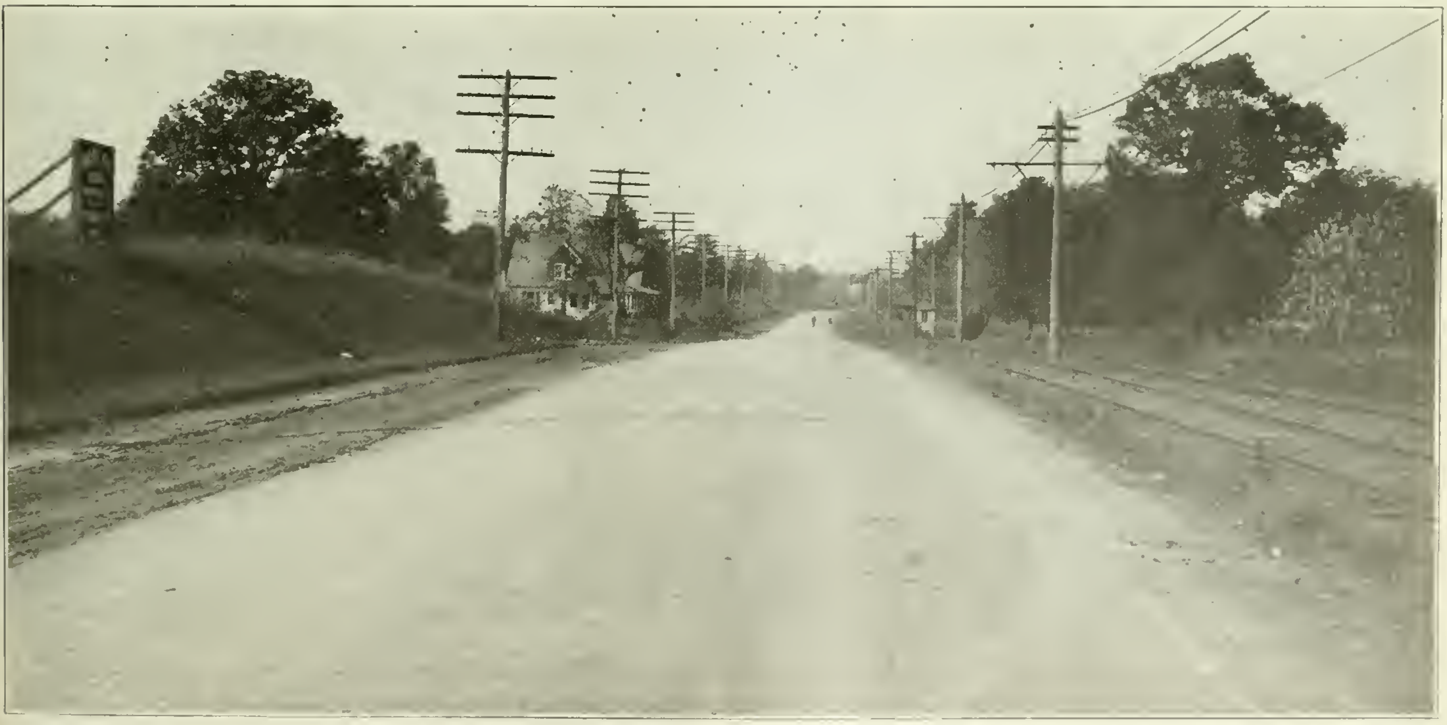


Fig. 2. Asphalt Macadam at Baltimore, Md., Built in 1910 by Penetration Method Using Trap Rock and 2 Gal. Asphalt Per Square Yard.

Concerning the respective merits of the penetration and mixed methods, highway departments have been successful with both, with the preponderance of opinion probably in favor of the mixed method. As is the case with all types of highway construction, however, many of the reasons advanced in favor of one or the other of the two methods are largely theoretical. This is demonstrated by the fact that the two types have proved to be equally efficient under corresponding practical tests, and it is fair and reasonable to judge them upon that basis.

As previously stated, public sanction of a proposed improvement is largely, if not wholly, governed by the first cost of the project, and in view of the fact that the penetration method would represent a saving of $2,000 or $3,000 per mile over the mixed method, there would be less difficulty in obtaining required appropriations for the cheaper type of construction. There should also be considered general availability of mechanical equipment, a factor decidedly in favor of the penetration method.

In so far as labor and materials are concerned, the penetration method involves little beyond the processes attending the construction of waterbound macadam roads. Rather the process is one of elimination in some respects, as the penetration method does not require the small stone and fine material constituting the binding material of waterbound macadam. Larger stone can be used for the penetration road, resulting in increased stability. Therefore engineers and contractors who have had experience in building macadam roads are, with the slight modifications mentioned, on familiar ground up to the point of applying the asphalt binder, which is not a difficult matter.

The contractor's equipment over and above that required in macadam construction would consist of kettles and a distributing wagon or pouring pots.

Thus no obstacles having to do with the construction details of the penetration method present themselves.

While the penetration method has not been standardized, processes vary but slightly in fundamental features. Perhaps the most marked departure from common practice is that of the Massachusetts Highway Department, where larger stone and more asphalt are used in the top course. The department recommends, and has used successfully, a surface of trap rock 1½ to 2½ in. in size. Where traffic is heavy, a 3-in. course of the stone is used. The stone is rolled before the asphalt is poured. In applying the asphalt the Massachusetts department prefers distributors to hand pouring, the material being applied at 300° to 350° F. under a pressure of 60 lb. Where hand pouring is done light rolling is recommended so as to permit the binder to penetrate by gravity. The finishing provides for a thin layer of pea stone and a seal coat of a half gallon of asphalt per square yard. The department is convinced that 1½ to 2½-in. stone insures greater stability than smaller stone. Mr. F. C. Pillsbury, Division Engineer of the department, says: "The large stone, it has been found, binds together more firmly than smaller stone and consequently is subject to less wear from the grinding of one fragment against another in the body of the pavement due to the passage of vehicles over the road surface. Small-sized stone tends to loosen quickly under this grinding action."

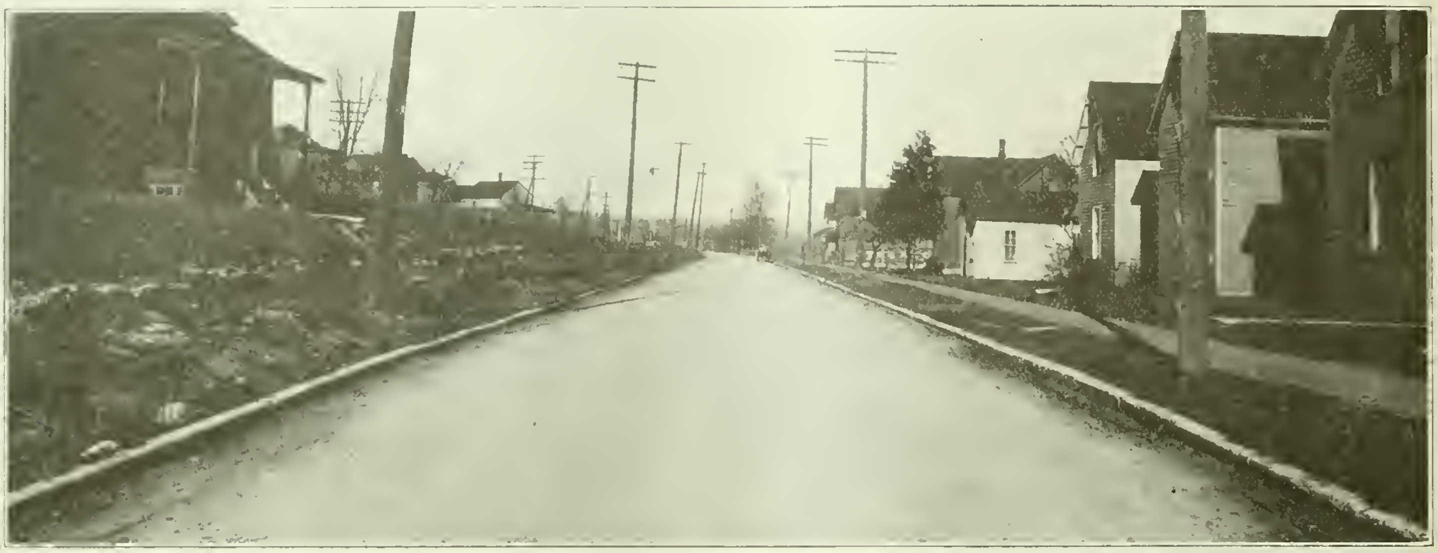


Fig. 3. Resurfaced Road Built in 1913 at Wabash, Ind.

The fact that the Massachusetts department has resorted to the penetration method on such highways as Hale St., Beverly, a heavily traveled road along the "North Shore," may be taken as evidence of the department's confidence in the type where subjected to extreme traffic stress.

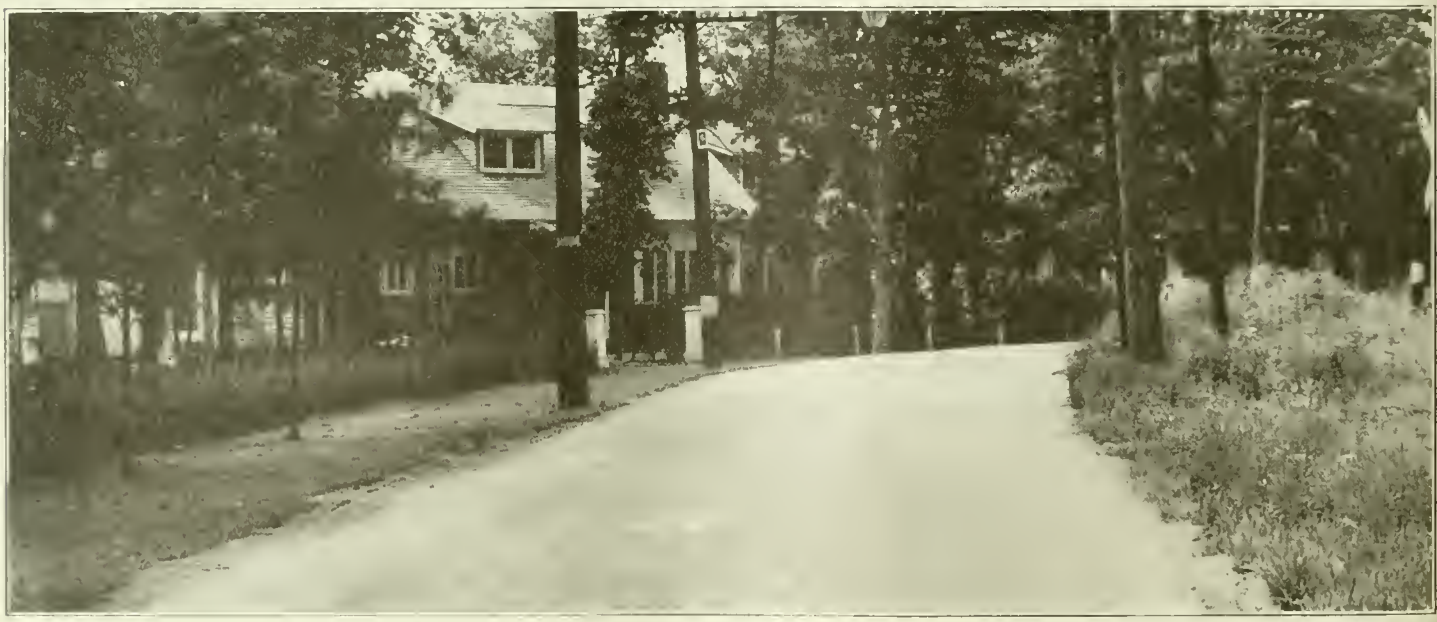


Fig. 4. Asphalt Macadam Road in Lucas County, Ohio, After Four Years' Service.

Among longer time tests of the resurfaced road may be cited a section of Park Heights Ave., near Baltimore. This stretch was built and bound with natural asphalt in 1910, the work being done by the Maryland State Roads Commission. Chief Engineer Shirley stated as recently as March 7 that the section in question had had practically no maintenance in the last four years and that prior to that time he doubted very much if there was any expenditure for maintenance. This record of six years' successful resistance to constant traffic of every description would seem to substantiate the claim that the penetration method offers much in the way of economy and efficiency in seeking to utilize and put in the permanent class our many hundreds of miles of old stone and macadam roads.

Success has attended the construction of this type of road in states other than those mentioned, notably New York, Pennsylvania, Indiana, Ohio and Florida, showing that climatic difference is not a retarding factor.

Concerning cost data on the penetration road, construction cost, as in the case of all roads, is governed largely by local conditions affecting the price of materials and labor. It would be fair to state that construction cost will range from $5,000 to $7,500 per mile for roads of standard width. Taking $7,000 per mile as a basis of comparison with other roads, this sum at 5 per cent would mean a carrying charge of $350 per year. Many communities are paying $16,000 per mile for new roads of the permanent type on which maintenance has not been lower than on the resurfaced asphalt-bound road. The latter figure would mean a carrying charge of $800 per mile per year, or more than twice the carrying charge where foundations of old stone roads are utilized to carry a new asphalt surface. The saving of $450 per mile in interest charges alone would be far in excess of the already determined maintenance on resurfaced roads, and the money could be used for further resurfacing in the manner described.

The accompanying illustrations of roads resurfaced and bound with natural or lake asphalt have been selected with special reference to volume of traffic as well as long-time tests under varying climatic conditions.

TEMPERATURE STRESSES IN A SERIES OF CONCRETE GIRDER SPANS UNDER DIFFERENT CONDITIONS OF END SUPPORT.*

The following summary of the results of an investigation made to determine the most favorable arrangement, to resist temperature stresses, of a series of concrete girder spans supported on concrete piers, is of interest and value; in our summary we have omitted the derivation of general formulas:

The investigation was made in connection with the design of a viaduct over the tracks of the St. Louis, Iron Mountain & Southern R. R. at Little Rock, Ark. The design finally agreed upon consists of a series of six simple girder spans, the outer girders of which have somewhat the appearance of arches. The three east spans are each composed of eight steel girders covered and decked with reinforced concrete, while the three west spans are each composed of eight reinforced concrete girders with an integral reinforced concrete deck. All spans are supported on solid concrete piers, 3 ft. wide at the coping. Although the piers are similar in design they have different angles of skew, and therefore different degrees of stiffness in the line of the viaduct. The concrete spans, which alone will be considered here, are approximately of constant section except as to the amount of reinforcement. Figure 1 shows diagrammatrically the general conditions of design. The outer or sidewalk girders of the concrete spans are continuous over the two intermediate piers; the other six girders of each span are not. The areas of steel and concrete in the several spans and the respective average moments of inertia of the piers about axes perpendicular to the axis of the bridge are given in Table 1. The heights of the piers, shown in Fig. 1, are in each case given from the base to the neutral plane of the spans. Although these heights vary somewhat they are assumed equal in the investigation.

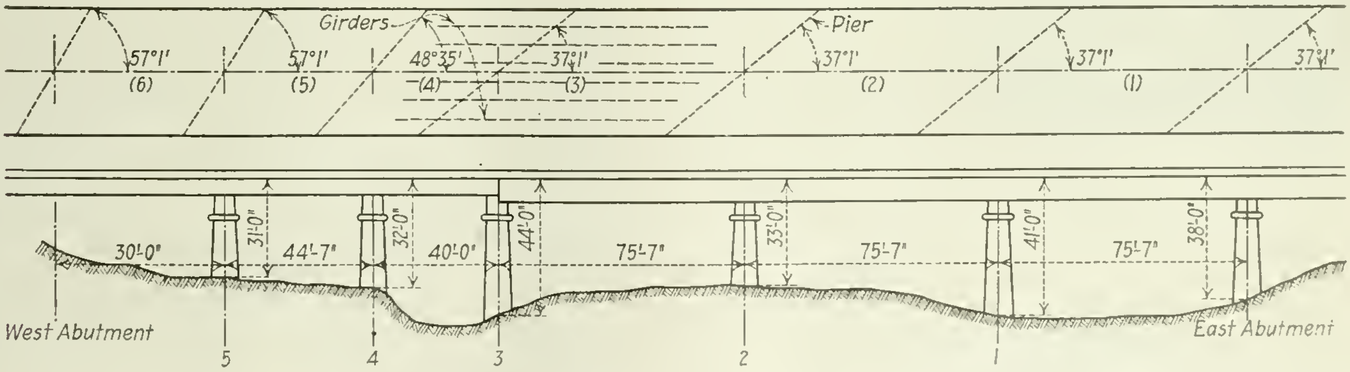


Fig. 1—Sketch Showing General Features of Design of Viaduct Over Tracks of St. Louis, Iron Mountain & Southern R. R. at Little Rock.

TABLE 1.—DATA ON CONCRETE SPANS AND PIERS.

Girder span.	*Area, sq. in	Average span, in.	Pier.	Assumed height, in.	†Moment of inertia, I.	Width, in.
6........	14,300	600	5	480	509,201,000	230
5........	13,960	536	4	480	752,342,100	275
4........	13,960	480	3	480	1,090,534,000	327

*Including steel in terms of concrete.

†$I = IA \sin^2 L + IB \cos^2 L$, in which L = angle between axis of pier and axis of I (perpendicular to viaduct axis), IA = moment of inertia of pier about its short axis, and IB = moment of inertia about its long axis.

E = 3,000,000; temperature range, 40° F.; coefficient of expansion, 0.0000055.

The problem arose from the proposal to build the three concrete spans integral with the piers and abutments, i. e., without provision for changes in length due to temperature and shrinkage. It is evident that the piers offer resistance to the free expansion or contraction of the spans which they support, and hence must introduce corresponding stresses. If these stresses are not negligible, and if expansion must be provided for, the problem is to determine how many expansion joints are necessary, and where they should be placed.

The results summarized in Table II were obtained for a change of 40° F. by the method of least work and the Castigliano theorem for one, two, and three spans of variable stiffness and inelastic abutments, the following cases being considered:

Case II. The three concrete spans monolithic, supported without friction on piers 3 and 4 and fixed with frictionless pins on pier 5 and the west abutment (see Fig. 1).

Case III. Spans supported without friction on the abutment and pier 3 and fixed on piers 4 and 5.

Case IV. Spans supported without friction on pier 3 and fixed on piers 4 and 5 and on the abutment.

Case V. Spans supported without friction on the abutment and fixed on piers 3, 4 and 5.

Case VI. Spans fixed on all four supports.

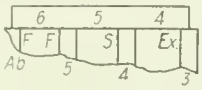
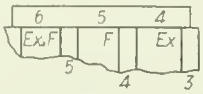
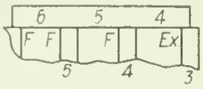
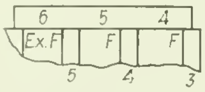
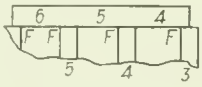
By referring to Table II it will be noted that there are given the average unit stress in each of the three spans and the unit bending stress in each pier for each of the five cases assumed.

The arrangement for Case VI causes severe stresses in all three spans and in piers 3 and 4. In the spans the stresses are increased from 72 to 92 per cent of the allowable, and the bending stresses caused in the piers are from 21 to 143 per cent of the allowable, assuming the piers to be of 600-lb. concrete. It will be noted that the stresses in the spans decrease as those in the piers increase.

---

*Summary of paper by Tresham D. Gregg, in Proceedings, American Society of Civil Engineers, Vol. XLII, p. 213.

TABLE II.—AVERAGE UNIT STRESSES IN SPANS AND UNIT BENDING STRESSES IN PIERS FOR VARIOUS ASSUMED CONDITIONS.

Case	Condition of ends of spans	Average unit stress in spans, lb			Unit bending stress in piers, lb		
		6	5	4	5	4	3
II		240	0	0	750	0	0
III		0	160	0	480	390	0
IV		480	400	0	145	1,090	0
V		0	250	300	755	115	600
VI		590	560	430	125	490	860

Note: Ex.=expansion joint; F=fixed on pier; S=sliding on pier.

For Case IV, with an expansion joint at pier 3, the temperature stresses in span 4 and in pier 3 are reduced to zero; those in spans 5 and 6 are reduced; and the bending stresses in piers 4 and 5, lacking the strong support of pier 3, are increased, pier 4 being stressed to 182 per cent of the allowable.

If, instead of placing a joint at pier 3, we place one at the abutment, as in Case V, the stresses in the spans are still further decreased, as are the bending stresses in piers 3 and 4. Pier 5, however, takes a heavy increase in stress to 126 per cent of the allowable unit concrete stress.

Now if we place expansion joints at both the abutment and at pier 3, as in Case III, we have the most favorable of the five cases considered. The stress in span 5 is only 27 per cent of the allowable, but the stresses in the piers are 65 and 80 per cent of the allowable; they can be neglected, however, as the direct stress is small.

For Case II the stress in span 6 is 40 per cent and in span 5, 125 per cent of the allowable unit stress.

The foregoing stresses will, of course, be modified somewhat by the fact that there actually will be considerable resistance at the expansion joints, due to friction.

The problem is now resolved into one of determining the relative economy of expansion joints and of reducing the maximum live and dead load unit stresses by increasing the section. Case III is the only arrangement with a restrained span which would not produce prohibitive stresses in at least one of the piers. It should be noted that increasing the section of span 5 will increase the stresses in piers 4 and 5 in direct proportion.

The plan finally adopted was to place expansion joints at the abutment and at pier 3 and a sliding joint over pier 5. The steel encased spans in the east half of the viaduct are all provided with expansion joints.

Those responsible for the design of this viaduct were I. L. Simmons and C. E. Smith, bridge engineers, respectively, of the Chicago, Rock Island & Pacific and the St. Louis, Iron Mountain and Southern railroads. The writer was engaged in preparing plans for the structure.

Hot Lunches and Efficiency.—It is claimed that the falling off in efficiency shown in the afternoon by laboring men is due in large measure to eating a cold lunch at noon. For this reason some contractors are beginning to experiment with containers designed to keep hot the lunches and drinks of their men.

CONCRETE STREET RAILWAY TRACK FOUNDATION CONSTRUCTED BY PENETRATION, BALTIMORE, MD.*

By R. Keith Compton, Chief Engineer, Baltimore Paving Commission.

Owing to the flat refusal of the traction authorities to install permanent construction, many of us have had to resort to legislative bodies for relief. In the beginning of the year 1914 the situation in the city of Baltimore was thoroughly studied, both by the municipal engineers and the traction officials, with the result that the State Legislature of Maryland was appealed to by the municipality and a law was passed putting the character of foundation under the ties of the several street railway companies and steam railroads under the jurisdiction of the Paving Commission, with power to decide whether such foundation should be of plain ballast or concrete. The Commission decided that in heavy traffic down-town streets concrete construction, 6 in. thick, under and around the ties, was necessary, but that in the outlying suburban sections where the traffic is light and street development more or less of an uncertainty, awaiting property development, rock ballast could be used.

In the downtown business section of Baltimore the streets are not over 40 ft. in width between curbs, and there is no room for a temporary third track. Furthermore, the gage is of odd dimension, 5 ft. 4½ in., so that the track area takes up more space than in most cities. It was also impossible, owing to congestion, to divert the cars to other streets. In order, therefore, to meet the conditions it became necessary to install the concrete without interruption to car traffic. It was at first thought that this could be done by blocking up the tracks an inch or so above the exact grade, installing the concrete, allowing it to set, then lowering the tracks to the proper and exact grade. The conclusion was reached, however, that this method would not only be very expensive, but hardly feasible, so that it was then determined to pursue the penetration method. This was done by bringing the tracks to the exact grade and ballasting with crushed stone from 1½ in. to 2½ in. in size, free of dust and small particles, and tamping the same thoroughly as in ballasting ordinary track, to carry the strain of passing cars, then applying a thin cement grout.

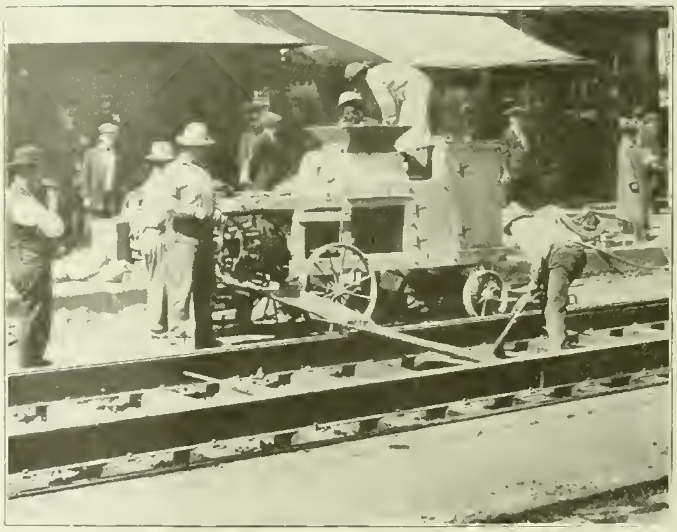


Fig. 1.—Grouting Stone Ballast for Track Foundation.

The forces of the railway company and that of the paving contractor work in conjunction. The railway area is first graded out to the subgrade of the paving by the paving contractor. The railway company then takes charge and grades out to a point 6 in. below the bottom of the ties. New rails and ties are then installed where necessary, together with any new special work. The ballast is then placed and thoroughly tamped under the ties and up to a point 2 in. above the bottom of the ties, the rails are brought to the proper grade and line, and when the entire construction is "tight" the penetration begins.

---

*Extracts from a paper read at the Pittsburgh convention of the American Road Builders' Association.

The grouting mixture is composed of 1 part cement to 2 parts sand, and is of about the consistency of thin cream. The mixture is applied without interruption to car traffic by the use of a small continuous mixer (known as the Coltrin Mixer) placed just outside of and parallel with the railway tracks, with a flexible chute, in two sections, to convey the grout from the mixer to the ballast. Starting on the downgrade end and working upgrade, the thin grout is penetrated into the stone ballast. The chute is flexible and in two sections. When a car comes along the first section is thrown out of service and the second section is lowered to the ballast at about the ends of the ties and the mixer kept in service. After the car passes the first section is thrown back in service.

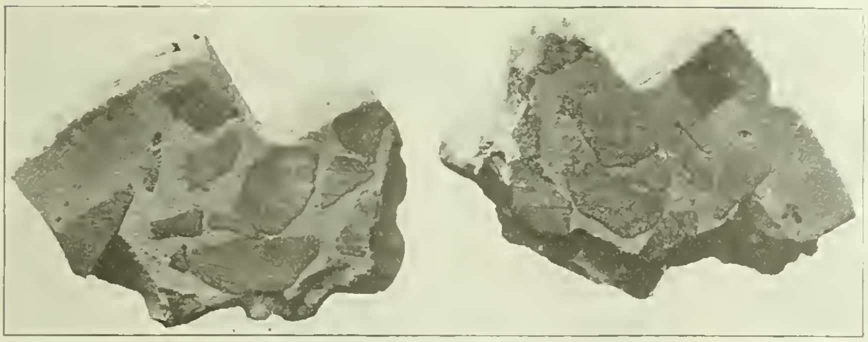


Fig. 2—Samples of Grouted Ballast for Track Foundation.

During this operation some movement occasionally occurs in the tracks, but there is a city inspector on the work at all times who hunts for and locates loose ties and they are immediately tamped up with green concrete.

The natural supposition is that sufficient movement of the ties and track would occur to injure the concrete while setting, but this is not true if the work is carefully handled and executed. On one street in Baltimore this work was successfully handled with five different lines of cars passing up and down the street with but 20 seconds headway at times during the day, while on another piece of work it was successfully handled with eleven different lines of cars passing over the special work with less than 20 seconds' headway at short intervals during the day. The resultant mixture is about 1 of cement, 2 of sand and 5½ of stone, with the concrete very dense, as the ballast has been thoroughly tamped and voids reduced to a minimum.

This ends the work of the railway company, as after this section of concrete is installed, the paving contractor again takes charge, installing the concrete base for the pavement immediately on top of the railway base, and then the paving.

As a rule, there is no bond between the paving slab installed by the railway company and the paving base installed by the paving contractor, because generally the former is several blocks ahead of the latter, and in the meantime the concrete slab has set.

One of the principal points gained by this form of construction is that it shows up very clearly every weak place during the progress of the work. All loose or poorly tamped ties are made apparent by the bubbling or oozing up of the grout as a car passes over. Failures in finished pavement are avoided by immediately tamping such ties, which in many cases would otherwise be overlooked. It has been found by careful cuts made in the finished work that this grout when properly applied penetrates the ballast to the subgrade, forming excellent concrete, and insures solid track construction, free from vibration.

From records kept and compiled by the Paving Commission it has been found that the total extra cost of this construction over plain ballast, including labor and material, is about 52 ct. per lineal foot of single track.

In the last two years about 10 miles (single track) of such construction have been installed in Baltimore by this process, in the busiest streets of the city, and our traffic interfered with to such a limited extent that no complaints whatever are heard from the traveling public during the course of the work. Included in the 10 miles of single track will be found all classes of paving within the railway area—sheet asphalt, wood block, granite block, vitrified block and scoria block.

In order to obtain good results with the penetration method, every detail must be carefully looked after by the inspectors, such as the quality and size of the stone composing the ballast, the tamping, and the mixing and placing of the grout. Frequent test holes should be cut in order to see that thorough penetration is secured, and wherever possible the penetration should be started at the downgrade end of a block and proceeded with the upgrade.

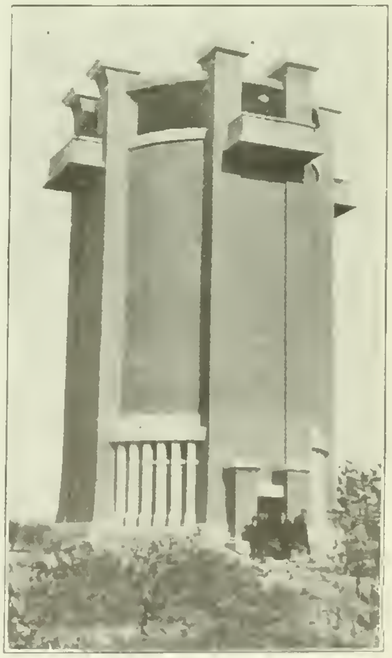
AN ORNAMENTAL WATER TOWER AT KENMORE, OHIO.

The water tower illustrated herewith stands on a high hill overlooking the village of Kenmore, Ohio. The brick casing encloses a steel standpipe with a capacity of 150,000 gal. The casing is of brick and cast concrete.

The cost of the steel standpipe was about $4,000 and of the brick casing was about $7,500 additional.

The tower was built in 1914 as a part of the water works installed for the village at that time. The works were designed by Pearse and Greeley, Consulting Engineers, Chicago, and Paul Hansen, in conjunction with F. L. Stone and the Payne Gillen Co., of Akron, Ohio. Mr. Albert C. McArthur of Chicago was the architect of the ornamental casing.

The finished structure is ornamental as well as serviceable. The people of Kenmore are much pleased with it and are glad they decided to add enough to their appropriation for the structure to make it an ornament rather than a perpetual eyesore. Already the extra cost is forgotten, but the good appearance of the structure continues to give pleasure to the people.



View of Brick and Concrete Casing for Steel Standpipe of Kenmore, Ohio, Water Works.

Between the steel standpipe and the brick and concrete shell, a space of about 4 ft., a spiral stairway leads from the ground to the observation balconies shown overhanging the structure's sides near its top. From these balconies a good view of the surrounding country may be had.

For this information and the photograph we are indebted to Mr. Samuel A. Greeley.

The United States Civil Service Commission announces a competitive examination for valuation analyst for May 9. Two grades of eligibles will be established, at $3,600 and $5,000 per annum, respectively. Most positions will be in Washington, D. C., but some may be in the field.

CURBS AND SIDEWALKS; SOME PRACTICAL AND AESTHETIC CONSIDERATIONS IN THEIR DESIGN AND LOCATION.[*]

By M. E. Chamberlain, Civil Engineer, Montevideo, Minn.

Even though of minor importance, curbs and sidewalks must be carefully considered in any complete street design; and the engineer should lead in emphasizing the importance of comprehensive plans. Straight lines and conventional designs are of doubtful value. The design of street details demands an appreciation of the street's ultimate use. This appreciation involves consideration of the topography, drainage, future traffic, street fixtures and use of abutting property.

Business streets are necessarily formal, allowing little opportunity for the exercise of civic art, but out of consideration for the eight or ten pedestrians who cross a business street to each wheeled vehicle that travels it, the passage from curb to pavement, and vice versa, should be made convenient.

Along residential streets the width of walks should be simply adequate for reasonable anticipated use. The distance between curb and buildings ought to partially govern the sidewalk location. Only on very narrow streets may the walks be located immediately against the curb. Abrupt changes in sidewalk grades, to accommodate private driveways, should never be tolerated. Rather flat reverse curves to pass valuable trees are not only permissible, but their appearance and use are rather pleasing. Where conditions permit, a curved alignment on steep grades is desirable. The boundary between street and private property is only an imaginary line, and should not always limit sidewalk, or even curb, locations. Even in the built up districts the curb and sidewalk problem is occasionally susceptible of improvement. Protruding corners may be cut off and severe angles replaced by graceful curves.

The side-hill street problem is often a perplexing one. The solutions have involved amazing extremes. In some instances property has been materially damaged by thoughtlessly adhering to some "established" grade, or custom. It is not necessary to place the curb and walk at uniform elevations above the roadway. There are instances, however, in Minnesota towns, where thoughtless engineers are following this rule. They have evidently not learned that concrete construction and concrete rules are separable. Damaging property, without increasing either the usefulness or beauty of the street, is not good engineering. A typical cross section which has given some degree of satisfaction in at least one Minnesota town is elastic in its application. It provides for variable transverse slopes and practical adjustments of gutters, curbs and sidewalks. A slight increase in the height of the curb, and a considerable increase in the transverse slope between the curb and walk on the up-hill side of these streets, add to the appearance of such a street. Where necessary, a 20 per cent slope from the curb up to the walk is not objectionable. For the benefit of property on the low side of the street the curbs may be located considerably nearer the low than the high side of the street, thus permitting of a reduction in the street grade elevation. These variations in design minimize the damage to elevated or depressed residence property. In extreme cases the walk has been narrowed, and occasionally placed at the curb.

Another difficulty often involved in the side hill problem is the unnecessary distance between curbs. On our average residence street much too great a percentage of the total street width is used for roadway. Increasing the distance between the curb and sidewalk makes a better and more economical street; 24 ft. between curbs is ample on ordinary residence streets. Ordinarily curbs should be no higher than the storm water capacity of the gutters demand. Sidewalks should be at least 1½ in. above the newly surfaced abutting earth. The mistake is often made of placing these two surfaces at the same elevation. By reason of dust and dead grass accumulations the surface of a well-kept lawn soon becomes from 1 to 2 in. higher than its surface was when newly graded; the natural result being poor drainage from the walk surface. On steep grades corrugations running diagonally across the walk hasten the flow of storm water to the side.

In hilly towns sidewalk steps are occasionally a necessity. The designer of them should remember that walking on the street is usually more rapid than walking indoors. Hence the treads of sidewalk steps should be considerably broader than for indoor stairs; 15 in. is a practical width, the risers being approximately 6 in. A long flight in one Minnesota town has treads of 40 in. The acrobatic feat of repeatedly approaching the risers with the same foot produces a tiresome feeling of deformity. Series of 15 in. treads, separated by landings, would have been a better design.

---

[*] Extract from a paper read at the annual meeting of the Minnesota Surveyors' and Engineers' Society.

A SMALL DOMESTIC WATER SUPPLY SYSTEM IN THE PHILIPPINES.

The water supply for the town of Balayan has been completed. The town has two good flowing artesian wells, one, to which the system is connected, flowing about 250 gal. per minute at ground level, the water rising 25 ft. above the ground. A standpipe, illustrated herewith, of 1,300 gal. capacity, was used to give pressure, connected with a 6-in. pipe to the main street, 3-in. pipe on all principal streets, and 1½-in. pipe on side streets.

The system will deliver water to the second story of any house in town and makes a very good supply for domestic purposes.

View of Corrugated Iron Standpipe, 3x25 ft., for Domestic Water Supply of Balayan, Batangas, Province, Philippine, Islands.

The hydrants on the 3-in. mains are made with a 2½x3-in. tee with a butterfly bibb on one side for supply purposes, and a plug on the other for use in case of fire after the town has secured a suitable fire engine.

The system with 4,920 ft. of street mains and 15 hydrants, including cost of stand pipe, installation and surcharges, cost the town $4,350.

The monthly rate for all houses connected is 50 ct., and since practically all houses are connected and the cost of operation is zero, the system is a good paying investment.

Engineering and Contracting

Devoted to the Economics of Civil Engineering Design
and to Methods and Cost of Construction

EDITORS

H. P. Gillette | C. S. Hill | C. T. Murray | S. C. Hadden | C. W. Malcolm

Volume XLV. CHICAGO, ILL., APRIL 12, 1916. Number 15.

INTEREST IN THE ACTIVITIES OF THE INDIVIDUAL.

From many quarters indications have come to us that the personal notes printed in our Current News section, under the caption of Personals, are widely read. This is one of the news features with which the professional journal is pleased to indulge its readers and itself. We call attention to it at this time because we desire the co-operation of our readers in improving it.

The information from which these brief notes are compiled is received from various sources. The editors prefer to get their information at first hand from the person mentioned. Many of our items are based on such information. A few of our readers keep us posted on their movements and we wish more would do so.

We, therefore, extend an invitation to the readers of this journal to notify us of their promotions, their new jobs, etc., so that we can make note of such matters in our Personals department. There need be no hesitancy on the part of the reader in extending to us this form of co-operation. It is not an evidence of vanity to report one's activities, but the failure to do so may be.

It is likely, though, that most engineers think their movements are of interest only to themselves, and for that reason neglect to take the action here suggested. It is a mistake for any man to make such an assumption, and particularly is this true in the case of the engineer. The engineer moves far and often. He makes many friends and becomes separated from them, but his interest in what they are doing continues.

THE TEACHING OF ENGINEERING CONSTRUCTION METHODS.

We are not quite certain that the fact is fortunate, but the demand for engineering school graduates favors men who can perform paying work at once. Engineering school training then has the object not merely of training a man to render in time high service as a constructor but also the object of training a man to be able to render service worth pay at the earliest possible moment. The American college boy is preponderantly the boy who must immediately after graduation carry the burden of self-support. Often he must bear some portion at least of this burden while he is yet in school. No school supported by public taxes may disregard these facts, primarily its teaching must fit men to be immediate money earners in the vocation for which they are undergoing schooling. It is one of the major attainments of the engineering school that it has met this requirement and yet not lost greatly its accomplishment of an education in the fundamentals of engineering scholarship.

When the editor left college more years ago than he sometimes likes to contemplate, there were not many things, as he sees the facts now, which he could do in engineering work with certainty of profit to his employer. There were also in those days not many employers who credited engineering college graduates with ability to make them any profit without considerable intensive reeducation. The capacity of the graduate and the mental attitude of the employer are much extended. A man who has acquired fairly well the instruction given him in college is today able to give profitable service in many tasks of engineering. Employers having come to the knowledge of this fact, are rather glad to secure for these tasks the college graduate in preference to less completely educated men. It must not be forgotten that these changed conditions are the accomplishment of the engineering school so let us not gird the professor more than need be.

But while the engineering graduate is capable immediately of giving profitable service in many tasks he is not similarly capable in other tasks no more difficult and quite as important. As a class the tasks, which he can perform profitably are tasks of designing. He has little ability in construction. He can usually come much closer to producing a good plan for a concrete abutment than he can to making a selection of machinery and arranging a plant layout and construction organization for building that abutment at least expense. There are good reasons why this is so but there is no good reason why it should be so to the extent that it is. Knowledge of construction can be given in school exactly as perfectly as can knowledge of design. A boy can learn the mechanism of a concrete mixer and the qualities that go to make a good concrete mixer more easily than he can learn the same things about an engineer's transit instrument.

One can think of a number of reasons why construction processes are not taught in engineering schools but only two reasons will be considered here. First is the somewhat vaguely differentiated but still firm belief that this kind of knowledge is contracting and not engineering. Second is the notion that by personal experience only can one come to useful knowledge of the kind. These two reasons are particularized because they furnish opportunity for argument that construction methods should be taught in engineering schools and also that they can be taught effectively.

If knowledge of construction methods is contracting knowledge rather than engineering knowledge it should be given because engineers are engaging more numerously every year in contracting work. Not only are many engineering graduates taking service with contracting firms but a great many of the present generation of contractors are men originally educated and practically experienced as engineers. Finally contracting is construction engineering. The day is not past when contractors develop from the pick, power be to them, but the day has come when the pick man comes more and more rarely to the high estate of financing a construction gang pay roll. Contracting is a more complex business than it was and to succeed at it calls for greater technical skill and acumen and in these the educated engineer has the advantage of starting farther ahead. Contracting is becoming exclusively a machine performed task and in plant selection and co-ordination and operation the engineer has again the advantage of a better start. Contracting has become in all its major manifestations construction engineering of high character.

For a decade the practice has been increasing of performing engineering construction without the intermediation of the contractor. Under engineers as directors construction plant and forces are organized and construction is prosecuted directly by the community, corporation or individual owner. The Panama Canal and the Los Angeles Aqueduct are notable examples of force account construction and the number of minor force account works is legion. For this service the engineer student should receive special training in construction operations. This training commands higher compensation than does minor designing. Fitting students in school to give it affords a new outlet for engineering college graduates.

On the two counts outlined we contend that the engineering school should give instruction in construction processes. Can effective instruction be so given? "Experience is the only teacher" one hears from all sides with wise wagging of heads. Let this be true. Whose experience? Certainly not merely one's own experience. The sum of the experience of any individual even after long years of practice is very small when set against the accumulated experience of the multitude of practitioners. Transmitted experience of others makes up the greater part of everyone's possessions of experience. Experience in construction can be transmitted as readily as can experience in design. The manner of transmitting construction experience must probably be different but the difficulty extends no farther.

The accumulation of recorded construction experience has been enormous in recent years and there are now available goodly sources from which to draw in teaching construction methods and costs. The camera, the stereopticon and the motion picture projector permit visualizing in a class-room every phase and movement of construction operations. Even time-motion recording devices are available for evaluating any variety of manual or machine processes. All about are construction tasks in progress and open to inspection and analysis. The means for teaching construction engineering are as plentiful as for teaching engineering design or strengths of materials or any other knowledge conveyed in engineering schools. Indeed the wealth of means for conveying instruction reduces the problem to gleaning time for reception by the student of the instruction which it is practicable to give him.

The profit to the engineering school of catering to the engineering construction market scarcely needs proof. The demand is great and it is increasing for men who can plan and superintend construction operations, can organize and manage men, can record and analyze costs, can select and operate construction plant. It is not so great nor is the pay so great for men who can only design and compute and survey. The engineer as a builder is more needed by employers than is the engineer as a designer. This is not an assertion of relative superiority, it is merely a statement of fact.

THE CITY REPORT THAT CAN BE READ WITHOUT MENTAL SELF-FLAGELLATION.

City annual reports are published presumably to be read. The editor, to his chastening, must examine many city reports. Hardly oftener than once in twoscore examinations do three questions fail to press themselves: To how many readers does this report by any chance get? How many readers who get this report will actually read it? Who in any place, first scanning this report, would read it if he could avoid the task? Consider this task. Visualize the perfunctory introductions, the interminable scheduling of clerical data, the entire absence of analysis, deduction and summary. The ordinary city report is yokefellow to absolute worthlessness. Even the bureau head harassed with the duty of preparing it regards his production with scant respect.

Why again, some of our persistent readers will ask, vent spleen editorially on the city report? Well, for one thing, the compulsion of working through one city report about every three days for years heckles one's spirit to frantic outcry. But there is a better reason, indeed, a reason that is wholly worthy and high minded. The city government is a great corporation for constructing and maintaining public works and for purveying public service. In performing these duties it perforce accumulates each year a vast number of data and a fund of experience which if collated and analyzed and presented in print in intelligible language would form a veritable reservoir of useful information for all engaged in constructing and operating public works and, not least of all, for the citizen who is curious about the purposes toward which his tax money is directed. No greater expenditure of money and no undue amount of labor, but merely the purpose and intelligent effort toward it, are required to produce a city report crammed with analyzed useful information instead of the futile affairs commonly produced.

The city annual report can be made entirely readable. Occasionally one receives a report which is brimming with instruction to the engineer and which at the same time can be read in very large part with intelligent interest by the citizen not trained in public works administration. A report of this kind is that issued by Mr. William H. Connell, chief of Bureau of Highways for the city of Philadelphia. Except for two appendices and a few tables, which are directed to the technician, there is scarcely a paragraph of this report which any intelligent reader cannot peruse understandingly. This report is very largely straightforward narrative; diagrams and tabulations always puzzling and frequently unintelligible to the non-expert are absent in every form except simple summaries. The taxpayer is told plainly what is being accomplished, how it is being accomplished and in what way more can be accomplished. He is appealed to as a business man in the language that every business man understands. He is not told a thousand and one clerical facts of no interest to anyone but the accountants of the bureau which issues the report; he is given the balance sheet in which these facts are epitomized in conclusions of general application.

Finally, and to our expert readers very likely most important, in appendices are printed detailed reports on three or more engineering studies conducted by the bureau engineers. In these the appeal is to the technical student and expert. They are replete with details. They are purposely contributions to professional literature. They are written in the language of the technician. In a later issue we shall take occasion to consider further one of these technical studies. Their mention here is merely to emphasize the fact that the city report can be made to contribute directly to engineering knowledge.

THE LIFE OF PAINT.

A few years ago the editor went carefully through three large treatises on paint, searching for definite data on the life of paint, but found nothing. It is a curious fact that, despite the reams of paper that have been used to exploit the virtues of paints of all kinds, next to nothing has been printed on the actual life of given paints under stated conditions.

Wide variations in temperature and exposure to moisture, particularly within 20 miles of the sea, undoubtedly shorten the effective life of any paint on steel or iron. Perhaps the life may then be not more than a year, or possibly two years. On the other hand, paint on wood in a dry climate and not exposed to great temperature changes may last 5 or possibly 8 years. But few observers have ever taken pains to record and publish the actual life of paints used on buildings, bridges and other structures.

IS THE PRESENT PRICE OF STEEL RAILS TO BE RAISED?

We have become so accustomed to the fixed price of $28 per ton for steel rails that even an intimation of an advanced price comes as a distinct shock. Since the establishment of the present price in 1901 we have passed through periods of marked depression and of prosperity which have greatly affected the price of all steel products except rails, yet the $28 price for rails has been maintained by manufacturers. That an increase in the price of rails is imminent is evidenced by the following statement issued by E. H. Gray, chairman of the United States Steel Corporation:

> Subsidiary companies of the United States Steel Corporation, which manufacture rails, have decided to maintain present prices until May

1, 1916, as to rails sold for delivery up to May 1, 1917, but will make no commitments beyond that date.

It has been understood for some time that the marked advances in other steel products have caused independent manufacturers to favor an upward movement of rails to a price more in keeping with those of other steel products, but they have hesitated to act so long as the Steel Corporation has shown no disposition to advance its price. In 1914 rail buying reached a very low point, but in 1915, especially during the latter part of the year, railroads were quite active in placing rail orders. However, there still remains a large tonnage to be placed, and a marked advance in rail prices would have a serious effect on many railroads. It now appears that the crest of high steel prices has been reached, and the effect of increasing rail prices in the immediate future is very uncertain.

In the past rail purchasers in general have not shown a disposition to question seriously the $28 rate, even during times of serious business depression, although there has been a tendency on the part of a few roads during the past year to purchase Canadian rails at a lower price. If the present fixed price is raised it seems reasonably certain that manufacturers will have great difficulty in maintaining a fixed and uniform price in the future.

STATE ASSOCIATIONS OF SEWAGE WORKS OPERATORS.

Few subjects discussed by engineers are more trite than that relating to the neglect of sewage treatment plants. Yet old as the subject is, the abuse is older still. We must continue to refer to it occasionally until practice in sewage plant maintenance and operation shows a marked improvement over that of the present time.

The long discussion of this subject is beginning to accomplish its purpose; the results are beginning to come into view. Sewage works operators are beginning to get together for the purpose of discussing their problems of common interest. Thus, last fall, a two-day conference for men engaged in the operation of sewage treatment plants, was held at the Iowa State College. The conference was called in order that the importance of the proper operation of such plants might be brought to the attention of those in charge. The program consisted of talks, demonstrations and a trip of inspection. A similar conference will be held this year. We hope an Iowa state association of sewage works operators will be formed at that time.

In New Jersey representatives of 16 cities met recently and organized the New Jersey Sewage Works Association. There will be an annual meeting and two other meetings each year at different sewage disposal plants in the state.

All the more populous states now have enough sewage plants so that there are available in each state enough operators to form the nucleus of a small association. Once formed such associations will grow somewhat slowly in members and much more rapidly in influence. State board of health and consulting engineers should promote the organization of these small associations.

EDITORIAL PARAGRAPHS.

It happens not infrequently that a letter soliciting a subscription to this journal is sent to a man who is already one of our subscribers. This causes us embarrassment, when brought to our attention, and it affects the subscriber in a variety of ways, depending on his disposition and the general state of his digestion when he receives the letter. Under the circumstances stated some subscribers are injured in their feelings. Others are amused and write us, with utmost good nature, that we are not as efficient, evidently, as we say others should be. It even happens at times that an old subscriber, who is a cherished friend of one or more of the editors, gets an invitation to subscribe. The remarks of such a man, when next we meet him, can be imagined. Now, what is the explanation of it all? Simply this: thousands of letters are going out, soliciting subscriptions, to lists which are first checked against our subscription list by some of the young people employed for that and similar purposes. Practically all duplications are caught, but now and then one is overlooked. Clerical errors occur in this business as in all others.

The "Earth Mover" of Aurora, Ill., the home of the wheeled scraper, says in reply to our editorial paragraph query of Feb. 9, 1916, that the inventors of the "dustpan on wheels" were Jesse Stubbs, a contractor, and William Schultz, a blacksmith of Mt. Pleasant, Iowa. The invention was made in 1877 and a year later it began to be marketed by the Western Wheel Scraper Co., organized by C. H. Smith & Co., Mt. Pleasant, contractors. Stubbs and Schultz and Smith are good old direct-from-the-soil names and their soil-moving invention has proved greater than any but a few.

The Chicago "Tribune" is prompted to speak thuswise: "There is a great deal of freedom in our custom of city government. The holdup man has some of it; dirt has some of it; politics has a great deal of it, and the average citizen is so unhampered—and unbenefited—by government that he would not know it existed if it were not for an occasional election. But as a way of conducting a big corporation it is a prodigious joke." All very true, but American belief in American political institutions, like American belief in American prowess, is an American myth. Trying conclusions with a myth is a fruitless performance.

Pavement maintenance, says that city's able chief of bureau, Mr. William H. Connell, has in Philadelphia "been one of the principal concerns of the public for over two hundred years." Pavement engineers, even in America, have some claim thus to pride of antiquity. In 1761 Philadelphia raised "by lottery" $50,000 for pavement construction. Herein is a suggestion to some of the cities who in 1915 "failed to market bonds" for pavement construction. In 1765 Philadelphia appointed a "scavenger" to supervise "the cleaning of the streets once a week." Today we are more polite and would call such an official Superintendent of Street Cleaning. To preserve its pavements Philadelphia in 1767 required "drays to have tires 4 in. wide." A goodly number of cities 150 years later have no such wise restriction. Finally, Mr. Connell tells us, the Franklin Institute of Sciences and Arts in 1843 formally opposed concrete base for pavement because it was "a barrier against the necessary access to the underground works of a city." Many persons still seem to think that pavements are put down to be taken up, but it is no longer good form to say so. By these things we observe that the world advances little by little.

That iron telegraph wire may have a life of 60 years is a fact rather surprising to engineers who have seldom estimated a life of more than 20 years. Mr. F. S. Lyman, engineer of the Interstate Commerce Commission, is authority for the statement that iron wire of the Western Union between St. Louis and Washington is still sound, although installed in 1856. It would probably be significant were a chemical analysis made of this wire.

Land values are often said to be independent of the value of the improvements upon the land. The fallacy of this contention is well brought out by the marked rise in city lot values in business districts following the invention of the "skyscraper." The fact is that land bare of "improvements" would usually have little or no value were it not for the possibility of putting "improvements" upon it. Value of real estate is the present worth of prospective net rentals. Rentals are a part of the production from the use of the real estate. The productiveness is a function both of the land and the building or other improvements. Here, as elsewhere, the degree of productiveness depends upon the combination of several factors.

COMPARISON OF WOOD AND CONCRETE FOR USE IN IRRIGATION STRUCTURES.

Contributed by S. T. Harding, Assistant Professor of Irrigation, University of California.

The relative economy of wood and concrete structures for use on irrigation systems is a question subject to much debate among irrigation engineers. The following comparisons were made to determine, first, the amount of wood in feet board measure which is the equivalent of one cubic yard of concrete in different types of structures and, secondly, to compare the relative cost for certain assumed conditions. The cost and conditions of use of these two materials will vary so widely in different portions of the West that the choice in any particular case will have to be based on a consideration of these local factors.

The comparisons which are made refer to the types of structures used on distribution systems. The choice of the material to be used in important single structures is often fixed by a consideration of other factors than the relative cost of the material used. The difficulties of replacement and damage from failure generally make the use of the more permanent forms of construction desirable for diversion dams and headgates.

The comparison of wood and concrete for the usual irrigation structures also involves more than considerations of first cost and the life of the structure. In new projects the location of parts of the distribution system, particularly sub-laterals, may need modification or change which involves less loss with the cheaper wooden structures. Also, a wooden structure has some salvage value; a concrete structure if removed is generally a total loss. Experience in operation or general advance in irrigation engineering may enable structures to be designed which may be more suitable than those first used. The methods of applying water to the lands may be modified. The present tendency is toward methods which permit of the handling of larger streams of water on the individual farm. This may require changes in the sub-lateral systems such as larger delivery turnouts and checks.

The financial conditions of the constructing company may be such that the initial expenses must be kept at a minimum until the project is placed on an operation basis. The interest rate at which funds can be secured in the earlier stages of a project is often much higher than those obtainable later, so that the cheaper wooden structures may be more economical for first construction, to be replaced by concrete. It may be economical where the period of development expected is longer, than the life of the wood structures to construct the canals and structures of only sufficient capacity for this early period and to enlarge the canal at the time of replacement. Concrete structures in the original construction would need to be built to full capacity and thus increase the amount of non-productive investment. This applies to structures in main canals and laterals, such as checks and flumes, more than to individual division or turnout structures.

When originally constructed, the canals may be in undeveloped sections without adequate transportation facilities. Following settlement, this may be overcome so that the relative prices of the two materials may be much different at the time the original wood structures must be replaced. The prices of the two materials has tended to change, wood increasing and cement decreasing, so that concrete may be able to compete with wood in replacements where it would not have been able to do so for the original construction.

These various considerations will fix the choice between these two materials for original construction more often than a strict computation of ultimate economy. After a project has been in operation sufficiently long to establish itself as a going concern, the replacements as needed can be planned with greater attention to the relative cost and service of the two types. This tendency is evident in practice, as on many systems side hill bench flumes have been replaced with retaining wall lined sections, wooden drops with concrete, etc. The comparisons here given will have a larger application in such betterment work than in original construction.

Ratio of Cost of Concrete and Wood in Structures to Total Cost of Structure.—The unit of cost for wood structures generally used is the 1,000 ft. board measure or M.B.M.; that for concrete, the cubic yard. These materials form only a part of the total structure, in both cases excavation, backfill, miscellaneous parts such as gates, footwalks, and footings for flumes are required. The proportion of the total cost, which consists either of the wood or concrete, was determined for many structures for which costs were available from various sources. The proportions vary rather widely with different conditions, but the following generalizations, Table I, were made. The percentages given are for the cost of concrete and wood in place.

TABLE I.—COST OF CONCRETE AND WOOD IN IRRIGATION STRUCTURES EXPRESSED AS A PERCENTAGE OF THE TOTAL COST OF THE STRUCTURE.

Type of strueture.	Conc. Structures			Wood Structures		
	Usual max.	Usual min.	Mean.	Usual max.	Usual min.	Mean.
Turnouts	75	50	65	65	40	50
Checks	85	60	75	75	50	60
Drops	90	60	80	75	50	65
Box culverts	95	60	80	70	50	60
Wood flumes	..	..	..	95	75	85
Buried concrete pipe siphons	85	65	75	..	..	..

Number of Cubic Yards of Concrete Which Are Equivalent to 1,000 Ft. Board Measure.—Comparisons of the amount of concrete or wood required were made for individual structures. Drawings of either wood or concrete structures were used and the amount of material for an equivalent structure of the other type computed. From these comparisons the number of cubic yards of concrete which were equivalent to one M.B.M. of wood were obtained. The resulting general figures are given in Table II.

TABLE II.—NUMBER OF CUBIC YARDS OF CONCRETE WHICH ARE EQUIVALENT TO 1,000 FT. B.M. OF WOOD.

Kind of structure.	Number of comparisons.	Usual max.	Usual min.	Mean
Turnouts	29	9.0	4.5	6.6
Checks	12	8.0	5.5	6.4
Drops	13	7.5	4.5	6.0
Box culverts	23	10.0	5.0	7.6
Flumes	13	5.5	3.5	4.2
Bridge floors up to 20-ft span	20	7.0	4.0	5.2

As shown in the table, the ratio varies widely. This is largely due to differences in design on different systems. Wood structures are better standardized than concrete, the commercial thicknesses of lumber are used, such as 2-in. plank for the smaller structures and 3-in. plank for the larger ones or those difficult to replace, such as culvert barrels. With concrete, the required thickness of such parts as headwalls for small structures cannot be definitely computed and practice varies with the policy of different forms of organization and climatic conditions. Examples were found of similar structures having over 100 per cent variation in the thickness of similar parts; the inlet floors to turnouts of similar size varied from 4 in. of plain concrete to 8 in. cross reinforced. In the comparisons it was attempted to use wood structures of equivalent heaviness of design to the concrete structure for which the comparison was being made.

If comparisons are made for straight wall construction, such as would be used in small head walls, the ratios in Table III will be obtained.

TABLE III.

Thickness of concrete wall. Inches.	Number of cubic yards of concrete which are equivalent to 1,000 ft. BM. of wood in straight walls	
	For 2-in. plank with 4x4-in. posts spaced 4 ft.	For 3-in. lumber with 6x6-in. posts spaced 3 ft.
3	4.0	2.3
4	5.3	3.1
6	8.0	4.6
8	10.6	6.2
10	13.2	7.7

Three-inch concrete walls have been used in some small structures with separately cast slabs. Four-inch walls have been used in favorable climates, particularly for those parts where forms were not required. A thickness of 6 in. represents the usual minimum where forms are used, especially when reinforcing is needed. Eight and ten-inch walls are used in larger structures where more than average strength is required or where generally heavy types of structures are adopted.

The structures included under turnouts include both lateral headgates and farm turnouts. The ratios for these, as well as for checks and drops, are less variable than for such structures as culverts. In these structures the thickness of the concrete is more often fixed by construction conditions than by any determinate stresses, and the design is as largely the result of experience as of theory. With culverts a wide variation in practice was found; the average ratio was higher than for any other type of structure. This is due most largely to the use of relative heavy barrels in concrete culverts. Such barrels require forms and the use of thin walls under favorable conditions is prevented where box culverts are used by construction conditions. Separate comparison of the inlets and outlets gave ratios for these similar to those for turnouts, checks and drops; for the barrels of box culverts the ratio averaged about 8.5. Pipe culverts in which the barrel is made of various types of pipe were not included in these comparisons.

The ratios are smallest in those types of structures where the concrete can be designed to withstand definite stresses of compression or as beams. This occurs in bridge floors and in flumes. Concrete flumes have been actually used to only a small extent as yet, due mainly to the difficulties in constructing the trestle members. Standard designs have been prepared for various sizes of flumes of both concrete and wood by the U. S. Reclamation Service, and equivalent sizes of these were compared for both the flume box and for bents 10 ft. high. The average ratio for the flume box was about 4.5 and for the bents 4.0. The cost per cubic yard of concrete in concrete flumes is greater than for other types of structures, and this excess cost may more than balance the smaller amount required.

The standard designs of slab and T-beam highway bridges of the U. S. Bureau of Public Roads were compared with standard designs of wood stringer bridges for the floors only for spans of from 8 to 20 ft. The average ratio for the slab bridges was 6.7, varying from about 5.0 for 8-ft. spans to 7.5 for 16-ft. spans. For T-beam forms of concrete bridges, the ratio varied from 4.3 for 10-ft. spans to 3.7 for 20-ft. spans.

The more usual comparison between wood and concrete which will be made in irrigation practice is for the more numerous turnouts, checks, drops and culverts. For flumes the comparison is more often between the wooden flume and other forms of construction, such as siphons or steel flumes. With bridges the choice is often determined by the fact that in many western States the county maintains the bridges after their original construction by the canal company. For the more typical irrigation structures, a ratio of about 6.5 cu. yd. of concrete to 1,000 ft. B. M. can be taken as an average with variations of from about 4.5 to 9.0 under different conditions, methods and policies.

Relative Cost of Wood and Concrete.—The choice between wood and concrete construction depends on the relative total cost. The ratio of the amount of concrete equivalent to 1,000 ft. board measure has been discussed. The relative unit cost also needs to be known, in order to make complete comparisons.

The unit cost of both concrete and wood in irrigation construction varies very widely. This applies both to the material cost and the cost of construction. The price of cement on the work is usually much higher than in the East. Aggregate may be expensive to secure and the haul to scattered structures is usually a considerable item. Also, even water for mixing, particularly on first construction, may have to be hauled considerable distances. Under such conditions the cost per cubic yard of concrete is naturally very variable. Under favorable conditions costs of $10 per cubic yard may be secured. This represents about the minimum for the usual small scattered structures; for larger single structures or linings the cost may be less. Under unfavorable conditions of material, or for thin walls requiring forms, the cost may be as high as $20 or $25 per cubic yard. About $12 to $16 per cubic yard may be taken for such structures, although where the costs vary so widely average costs should be used with caution.

The unit cost of wood in place also varies widely. The material price depends on the nearness to the source of supply and the wagon haul required. The labor cost of construction varies with the type of structure. For small scattered special structures or for high flumes, it may be as high as $20 per 1,000 ft. B. M.; for standard structures of which large numbers are used, such as individual turnouts where the framing can be done at central points, the cost may be as low as $6 per M. B. M. For usual conditions for structures except high flumes, the labor cost will generally be about $10 or $12 per M. B. M. The material cost varies equally widely. In localities near the sources of supply suitable lumber may be obtained for as low as $15 per M. B. M.; in others it may be as high as $30, averaging perhaps about $20. This gives a cost in place of from as low as about $20 to as high as $50 with an average of $30 to $40. These averages, as in the case of average costs of concrete, have a limited application. They give a ratio of average cost of 1,000 ft. B. M. to that of 1 cu. yd. of concrete of about 2½ to 1. If the average ratio of the quantities required is taken as 6.5 to 1 and cost as 1 to 2½, the ratio of the total cost of the lumber or concrete part of the structure will be 2.6 to 1. The cost of the other parts of structures as previously given is for concrete structures about 25 per cent of the total cost, or one-third of the cost of the concrete, and for wood structures 40 per cent of the total cost, or two-thirds of the cost of the wood in the structure. On this basis the average total cost of concrete structures will be about 100 per cent greater than that of similar wood structures. Where the price of lumber is high and the conditions for concrete are favorable, a condition more often found in parts of California, the cost of concrete structures may not be more than 50 per cent greater, and in some particular cases no greater, than equivalent wood structures. In the higher altitudes where lumber is often relatively low in price and the cost of concrete often relatively high, the concrete structures may cost 200 per cent or more in excess of the cost of wood structures. In all such comparisons the various previously mentioned factors besides first cost which affect the choice of material should not be forgotten, as such points as often determine the actual choice as the actual investment cost.

Maintenance and Depreciation.—Few definite data on the actual cost of maintenance of structures is available. Such costs would be difficult to obtain for smaller structures. In some systems operation and maintenance costs are not kept separate; in others all maintenance is carried in a single account. The life of wood structures has been observed under different conditions. The cost of maintenance is small for the first portion of the life of wood structures and increases in amount until replacement is warranted. The total cost of maintenance during the life of such structures may approach the first cost of the structure. With concrete structures the cost of maintenance should be small. Such maintenance is more often required for the auxiliary parts of structures, such as protection to the adjacent canal and repairs, due to accidents rather than to gradual depreciation. It should be fairly uniform from year to year.

The total life of structures varies with the type and the conditions of use. Concrete has not been in use sufficiently long to give data on its life. There is always a certain probability of failure through injury, such as undercutting, removal due to enlargement of the systems, or replacement with a different type of design.

The life of wood structures depends on the character of their construction and conditions of use. Generally structures set in earth, such as drops and checks, have a shorter life than the boxes of flumes set on well built trestles. Where the operation season is long, so that structures are kept wet practically throughout the year, there may be little difference. Records of wood structures under various conditions indicate that ordinary turnouts, drops and checks can be expected to have a useful life of 6 to 10 years for pine, 8 to 12 years for fir, and 10 to 20 years for redwood. Under favorable conditions redwood structures have considerably exceeded the figures given. For well built trestle flumes, the useful life can be expected to be 8 to 14 years for pine, 10 to 16 years for fir, and 12 to 20 years for redwood. Wood pipe under conditions to which it is suited should have a useful life exceeding these figures.

The cost of replacing structures is usually greater than their first cost. This is due to the fact that the excavation will be more largely hand work and to the cost of tearing out the old structure.

The salvage value of concrete structures is usually negligible; the lumber removed from old structures may have some value for use in forms, etc., being usually greater for flumes than for structures set in the ground.

Comparison of Cost of Wood and Concrete Structures on Investment Basis.—On the basis of the average figures previously developed, comparisons of the cost of wood and concrete structures can be made. This has been limited to drops, checks, turnouts and culverts, as these are the structures occurring in greatest number on irrigation systems and whose design and construction can be most closely organized. A comparison of such structures as high flumes will involve so many local and special considerations that a general comparison would be of little value.

The capitalized cost can be taken as the basis of comparison. Table IV has been worked out to show the ratio of first cost at which the capitalized cost will be equal for different conditions.

Interest rates of 6 and 8 per cent were used. Irrigation district bonds generally bear 6 per cent; the terms of sale, however, more often make the rate on the price received 8 per cent or higher. Western mortgage rates vary from 6 to 8 or even 10 per cent; this represents the value of money to stockholders in mutual companies or on systems where improvements are paid for by stock assessments.

Different lengths of life for the structures were assumed. The annual maintenance cost is estimated as a percentage of the first cost, a higher rate being used where the life of the wood structure was relatively short. Maintenance on the concrete was taken as zero. Salvage value was neglected; its amount would probably be less than the error involved in some of the other assumptions.

TABLE IV.—RATIO OF TOTAL FIRST COST OF CONCRETE AND WOOD STRUCTURES AT WHICH THE CAPITALIZED COST OF SERVICE BECOMES EQUAL.

Interest rate. Per cent.	Assumed life of concrete structures in years.	Assumed life of wood structures in years.	Assumed annual cost maintenance in per cent of first cost.		Ratio of total first cost of concrete structures to total first cost of wood structures at which capitalized cost becomes equal.
			Conc.	Wood.	
6	30	10	0	5	2.6 to 1
6	45	15	0	4	2.2 to 1
6	20	10	0	5	2.1 to 1
6	40	20	0	3	1.8 to 1
6	15	15	0	4	1.4 to 1
8	30	10	0	5	2.25 to 1
8	45	15	0	4	1.9 to 1
8	20	10	0	5	1.95 to 1
8	40	20	0	3	1.6 to 1
8	15	15	0	4	1.3 to 1

Table IV shows the ratios of first cost at which the capitalized cost of service becomes equal for these assumed conditions. For useful lives of 30 and 10 years for concrete and wood and interest at 6 per cent and annual maintenance on the wood structure of 5 per cent, a concrete structure costing 2.6 times as much as the wooden one would be equal in capitalized cost. The ratios are higher for the lower rates of interest.

Ratio of Cost of Structures to Total Cost of Canal System.—In comparing the relative economy of different types of structures, the proportion of the total cost of the canal systems which consists of structures must be known, in order that the proportion in which the total construction cost will be increased by different types of structures may be estimated. In some of the Annual Reports of the U. S. Reclamation Service, the total cost of structures and excavation is stated separately for some of the projects. From these and other records Table V was derived.

TABLE V.—USUAL COST OF STRUCTURES ON CANAL SYSTEMS EXPRESSED AS PER CENT OF THE TOTAL COST.

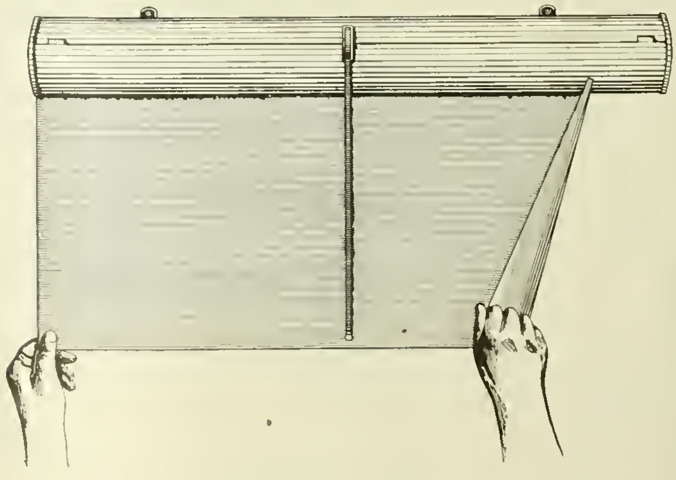
	Main canals.	Laterals.	Whole project.
Regular topography:			
Concrete structures	10-20	25-40	20-35
Wood structures	8-15	15-35	10-25
Irregular or steep topography:			
Concrete structures	20-35	40-50	35-45
Wood structures	15-25	25-40	20-35

The use of concrete structures costing twice as much as wood will increase the total cost of the canal system by from 15 to 30 per cent under usual conditions. This applies to the canal system structures only and not to diversion dams or to such conditions as side hill locations requiring bench flumes or lined canals.

Conclusions.—The preceding discussion of the factors involved in a choice between concrete and wood for irrigation structures, both for the factors for which numerical limits have been given and also for those not capable of numerical expression but which are of equal or greater importance, makes it evident that no general conclusions can be drawn as to the most economical type of construction. For any particular project where the construction costs can be estimated and the other factors, such as financial conditions of the constructing organization, rate of interest, certainty as to type of structure desired and permanence of its location can be given proper weight, a decision can be made. Under usual conditions concrete will be the preferable material if the capitalized cost of service alone is considered. The other factors are, however, more usually such as to incline the choice toward wood for first construction, except for the larger and more important structures. That the capitalized cost is being given more consideration and that many systems are reaching a condition where replacements and betterments can be made on a more permanent basis is evidenced by the increasing use of concrete in irrigation structures.

TRACING CLOTH OR BLUE PRINT PAPER HOLDER.

The sketch shows a convenient holder for drawing paper, tracing cloth, etc. The paper on a roll is inserted into the holder and as required is drawn out through the slot and cut by the cutting lip on the slot. An attached spring measuring tape gives exactly the length required. This holder is made of heavy japanned tin in 30, 36 and 42-in. lengths, listed at $4.50, $5 and $5.75 respectively. Kolesch & Co., 138 Fulton St., New York, are the makers.



Security Holder for Tracing Cloth or Blue Print Paper.

DESIGN AND CONSTRUCTION OF A HIGH-LEVEL REINFORCED CONCRETE HIGHWAY BRIDGE ACROSS THE SKURUSUND, IN SWEDEN.*

The Skurusund reinforced concrete highway arch bridge, completed during the latter part of 1915, spans the Skurusund Sound near Stockholm, Sweden, and connects the mainland with Varmdo Island. It consists of a central span of 236.22 ft., flanked by two spans of 160.76 ft. each, with a beam-and-girder viaduct approach of 213.25 ft. on the Skurn side and one of 114.83 ft. on the Varmdo side. The rise of the central arch span is about 105.0 ft., and that of each side span about 65.6 ft. The bridge has a total width of 24.6 ft., and provides a 16.4-ft. roadway and two 4.1-ft. sidewalks. Figure 1 is a view of the completed bridge. It replaces an old floating structure near the site of the new bridge.

The plans originally accepted by the authorities were for a steel structure providing a vertical clearance of 98.4 ft. and consisting of a 197-ft. simple span over the sound and short viaduct approaches. Before bids were called for the Argus Company, of Stockholm, submitted provisional plans for a reinforced concrete arch bridge consisting of a 196.85-ft. central span and providing a vertical clearance of 105 ft., and two side spans of 98.42 ft. each. The roadway of the main bridge was to be carried on spandrel columns and beams and that of the approaches on beams supported on high trestles. After considering various features of this reinforced concrete design the span lengths were changed to those given in the preceding paragraph, and the modified design accepted.

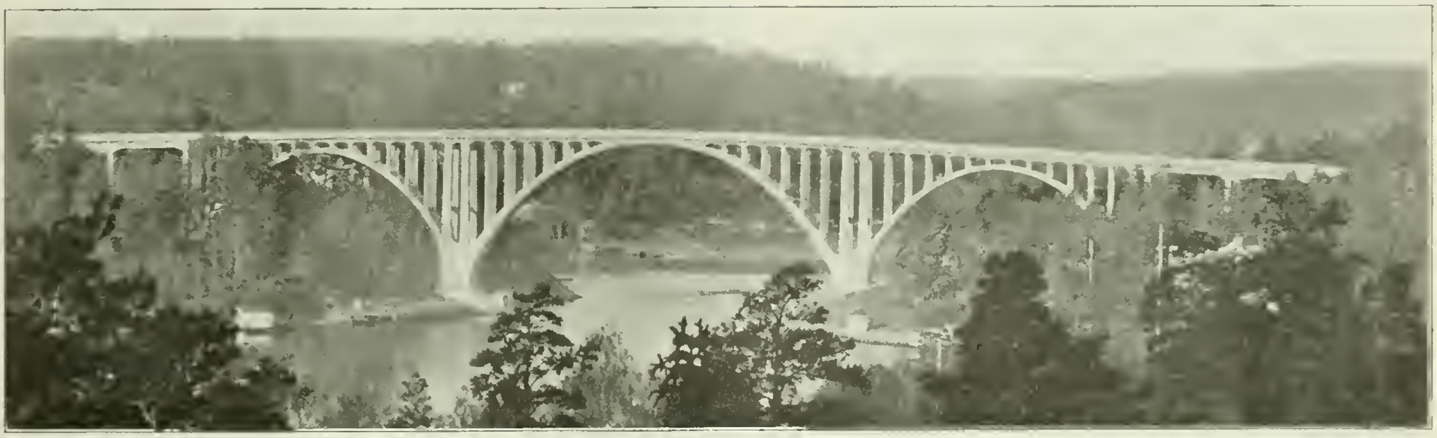


Fig. 1. View of Reinforced Concrete Highway Bridge Across the Skurusund Sound, Near Stockholm, Sweden.

A feature of the new bridge is the four-column arrangement at the end of each arch and viaduct span, this being a logical result of the expansion system adopted. The roadway is so divided by transverse joints that the beam viaduct spans are separated, and each arch with its roadway forms a separate system. Moreover, each system is provided with stiff bracing, which carries the wind load to the ground. To make the arches more stable they have been broadened as they approach the spring line.

Loads and Allowable Stresses.—The bridge was designed for the following loads, in addition to its own weight: live load on sidewalks, 102.4 lb. per square foot; live load on roadway, two rows of 5½-ton wagons, a 11-ton motor truck, and four-wheeled tram cars with 3.3 tons wheel pressure. The wind load on the unloaded bridge was taken at 51 lb. per square foot, and that on the loaded bridge at 30.7 lb. per square foot.

The maximum allowable stress due to the combined action of all the above specified loads which can act on any part of the structure was 16,400 lb. per square inch on the reinforcing steel, or, adding wind and temperature stresses, 20,500 lb. per square inch. The allowable compressive stress on 1:2:3 concrete was 819 lb. per square inch; on 1:3:3 concrete, 717 lb. per square inch; and on 1:5:7 concrete, 205 lb. per square inch. The allowable shear on 1:2:3 or 1:3:3 concrete was 82 lb. per square inch.

Details of Design.—The arches are of solid construction, as comparative calculations showed there would be no gain by dividing them into ribs.

The arches of the side spans have a clear span of 160.76 ft., and a rise of 65.62 ft. At the crown the arch rings are 21.98 ft. wide and 2.46 ft. thick; at the spring line the respective dimensions are 23.13 ft. and 4.0 ft. These arch rings are reinforced in both directions with ½-in. bars spaced 10 in. on centers.

The center arch has a clear span of 236.22 ft. and a rise of 105.0 ft. At the crown the arch ring has a width of 21.98 ft. and a thickness of 3.44 ft.; at the spring line the respective dimensions are 23.46 ft. and 5.90 ft. Although no reinforcement of the arch ring was actually required it was reinforced in both directions with ½-in. bars spaced 10 in. on centers on both its upper and lower surfaces.

The floor system consists of a reinforced concrete slab 6.3 in. thick, supported on five longitudinal beams spaced 4.92 ft. on centers. In the viaducts the longitudinal beams are supported by strong frame constructions, which receive the wind pressure, and in addition are so designed as to give with the expansion of the roadway. In the arch spans the longitudinal roadway beams are carried on cross beams supported on three braced spandrel columns, spaced 12.79 ft. apart. At the crown of the arch the roadway slab rests directly on, and is firmly connected to, the arch ring, and it thus expands in both directions. The longer spandrel columns can, without incurring excessive stresses, resist the bending caused by wind forces, but the shorter ones are not so designed. All spandrel columns have the same dimensions, 1.8 ft. square.

The roadway slab is waterproofed with asphalt felt. Above this there is a 3⅛-in. layer of porous concrete, on which rests the surfacing of tar macadam. The sidewalk is surfaced with the same material and is separated from the roadway by granite curbstones.

Construction Features.—Extensive falsework was required to support the forms, and that for the center arch required special skill and care. The construction of the falsework for the side arches offered no particular difficulties, as the supports rested directly on rock or on concrete bases. For the central arch it was first intended to place the falsework directly on lines of piles driven in the sound, but a careful examination of the bottom of the sound showed that in most cases the piles would have to be fixed in the rock, which had a considerable slope. It was therefore decided to arrange the main falsework in the shape of a fan, with one central support (see Fig. 2). Support for a portion of the falsework near the piers was obtained by placing concrete bases as near these piers as possible.

The depth of water in the middle of the sound was about 26 ft., the bottom consisting of loose clay and gravel overlying the rock. To as great an extent as was possible the loose clay was removed and replaced with gravel, and piles for the central support were then driven to rock. These piles were then cut off at the water level, and the falsework erected on them, leaving a passageway for shipping on each side of the support. Figure 3 is a view of the pile foundation for the central support of the falsework. This view also shows the end pillars carried above the spring line of the arch.

---

*Based on article by George Brockner in Concrete and Constructional Engineering for January, 1916.

Screw jacks were placed under the central falsework tower to permit adjustments and to enable the forms for the arch ring to be struck after the concrete had set. Figure 4 shows the arrangement of these jacks. Figure 5 is a view showing the procedure used in dismantling the falsework for the central span.

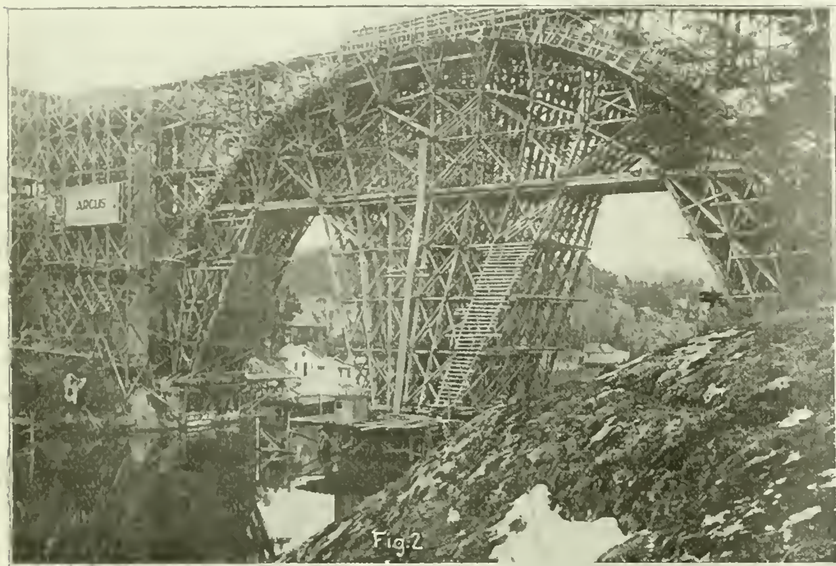


Fig.2

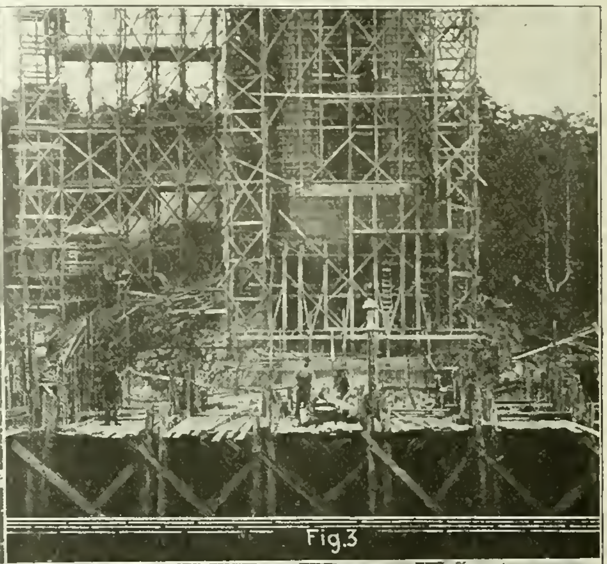


Fig.3

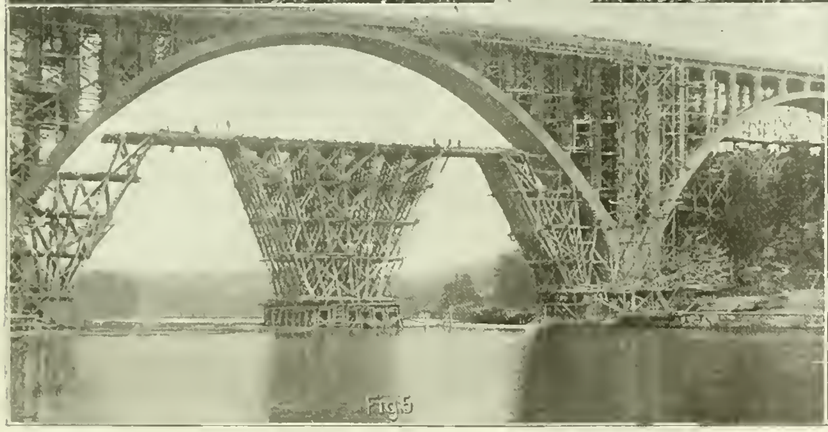


Fig.5

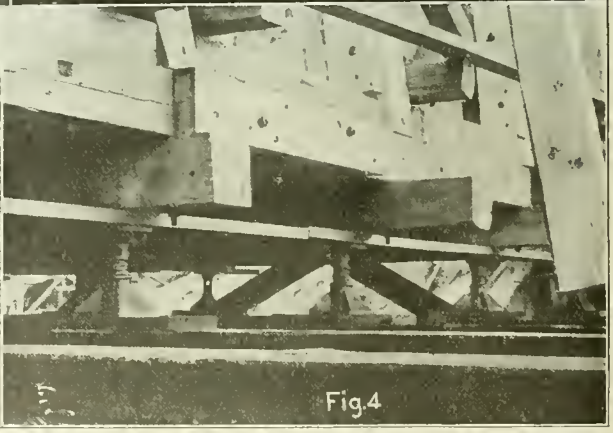


Fig.4

CONSTRUCTION VIEWS OF REINFORCED CONCRETE HIGHWAY BRIDGE ACROSS THE SKURUSUND SOUND, NEAR STOCKHOLM, SWEDEN.

Fig. 2—Falsework for Central 236-Ft. Arch Span. Fig. 3—Pile Foundation for Central Tower of Falsework for Center Span; View Also Shows Staging for Pillars at End of Span. Fig. 4—Arrangement of Screw Jacks Under Central Falsework Tower of Center Arch Span. Fig. 5—View Showing Manner of Dismantling Falseworks for Center Arch Span.

The materials were brought to the site in lighters and were handled by derricks. The steepness of the shores made it necessary to use separate transportation systems to the respective storage stations; these consisted of Decouville lines, along which the wagons were drawn by means of motor-operated winches located at the top of the lines. A motor-driven concrete mixer was installed on each side of the sound.

As no special treatment of the concrete surface was intended special care was taken in constructing the forms. The boards were placed according to a certain system so that the unavoidable marks would make a natural decoration of the otherwise large, blank surfaces.

The bridge contains about 7,060 cu. yd. of concrete, of which about 4,840 cu. yd. are reinforced.

Work was commenced in April, 1914, with the construction of the unloading docks, and with rock blasting for the intermediate columns of the approach viaducts. During the summer and autumn the viaducts, the side arch spans, and the spandrel columns nearest the sound were cast; and during the winter the construction of the falsework and forms for the central arch and the forms for the spandrel columns and roadway on the side arches were built. The pouring of the center arch ring was begun April 26, 1915, and the arch ring was completed May 20, after which the forms for the spandrel columns and the roadway were commenced. After the falsework for the large center arch had been lowered by means of screw jacks, about the last of June, the columns and the roadway of this span were cast. All the supporting structures were completed by the middle of July. The bridge was given its final test in September with a load of 123 lb. per square foot, this load causing no perceptible deflection.

The bridge was designed by Mr. Tor Kempe, and was constructed by the Arcus Company, of Stockholm, Sweden.

NOTES ON THE CHOICE, INSTALLATION AND MAINTENANCE OF WATER SERVICE PIPES.

The following notes give the outline of the preliminary report of the Committee on Service Pipes of the New England Water Works Association. Mr. William S. Johnson, Consulting Sanitary and Hydraulic Engineer, 101 Tremont St., Boston, Mass., is chairman of the committee and we are indebted to him for the outline here given:

The ideal materials for service pipes and fittings are not commercially practicable.

All services as constructed are certain to give more or less trouble after they have been in use, some within a few years and others after a considerable period of service.

Uncoated steel pipes are unsuitable for service pipes.

Enameled pipes have in the past given so much trouble that their use has been practically discontinued. We find only one department now using them for new services.

Uncoated wrought iron pipe is likely to give somewhat less trouble than steel, but is certain to give trouble within a few years.

Galvanized pipe lasts much longer than uncoated pipe, but with the majority of waters will fill with rust in time.

Cement lined pipes, properly made, give very little trouble at joints and fittings and from rusting on the outside. The troubles which do occur with cement lined pipes can be greatly reduced by using galvanized pipes and lined couplings. The use of cement lined pipes is increasing, especially in New England.

The old style lead lined pipes have always been unsatisfactory.

Lead lined pipe as made today gives practically no trouble except at fittings. This pipe has not been in use for a sufficient length of time to determine its life.

Lead pipe of proper weight is the most satisfactory material for services from a mechanical standpoint, as it is flexible and its life is very long. The chief trouble with services of lead is in the fittings.

The use of lead and lead lined pipe is condemned by health authorities as being unsafe with waters of a certain character, and even if the water now used does not dissolve the lead a change in the source of supply or filtration of the water may alter the conditions so that the water will attack the pipe and lead poisoning may ensue.

No consideration has been given to tin and tin lined or to brass pipes, as they appear to be at the present time commercially impracticable.

With the exception of the unlined steel or wrought iron, which fill throughout their entire length, the chief trouble in services appears to be at the corporation cock and at the connections with the brass fittings.

Much of the trouble at the corporation cock appears to be from the rust forming in the main pipe and covering the corporation. This can be remedied to a considerable extent by having the corporation extend well beyond the inside of the main.

Certain waters attack metals much more rapidly than others, so that the life of the service depends to a considerable extent upon the water.

The action of the water upon the pipes depends to some extent upon the quantity of water passing through the pipe. When there is little flow of water the action will be less.

The deterioration of the pipe from the outside is very serious in certain soils and inside the cellar walls. This is especially noticeable in the case of uncoated iron and steel pipes.

Pipes laid in clayey soils, in salt water marshes, ashes or cinders and near stables are quickly acted upon from the outside, in some cases failing within a year. The sprinkling of lime around the pipe when laid has been suggested and used as a remedy, but evidence is lacking as to the effect of this treatment.

The trouble from rusting of the outside of the pipe inside the cellar wall can be greatly reduced by inserting a short section of brass pipe, or by putting in a coupling so that the defective piece may be readily replaced. The use of a sleeve in the cellar wall has also been suggested.

The troubles from the filling of the pipe can be greatly reduced by increasing the size of the service. The difference in expense of a 1-in. pipe and a ¾-in. pipe is small and is apparently justified by the saving in expense of maintenance.

The use of galvanized pipe for lining with cement increases the life of the service, as it prevents, to some extent, action on the outside of the pipe. Painting the outside of the pipe with a preservative coating also appears to be effective.

Rigid connections with the mains with the omission of the gooseneck are used in a large number of places, and in some places exclusively. Comparatively few of the places where they are used report any trouble from such connections.

The advantages of the rigid connections are a saving in cost and a greater convenience in cleaning.

The advantages of the gooseneck are that it permits the drooping of the service below the main away from frost and permits the service to take any direction from the main.

The improved methods of cleaning service pipes make it possible to save a large sum which would otherwise be paid for digging up the services and for renewals.

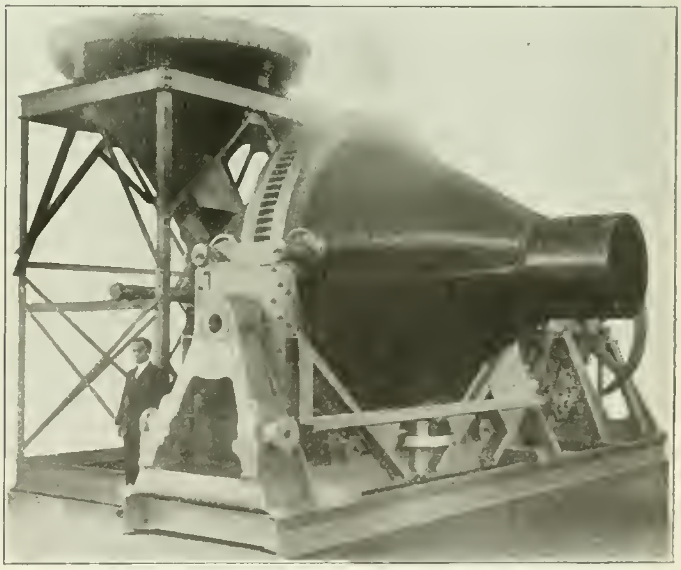
The use of the force pump and the wad of paper appears to be the most satisfactory in many cases, especially with lead pipes or when goosenecks are used.

The general opinion among superintendents in New England is that the water department should lay and maintain all services from the main to the stop and waste in the cellar.

Custom varies as to the payment for services, but in New England the general custom is for the department to pay for the service to the curb cock or to the property line. Outside of New England in the majority of cases the customer pays practically all of the cost of the service.

TWO FOUR-CUBIC YARD MIXERS FOR CONCRETE DAM CONSTRUCTION.

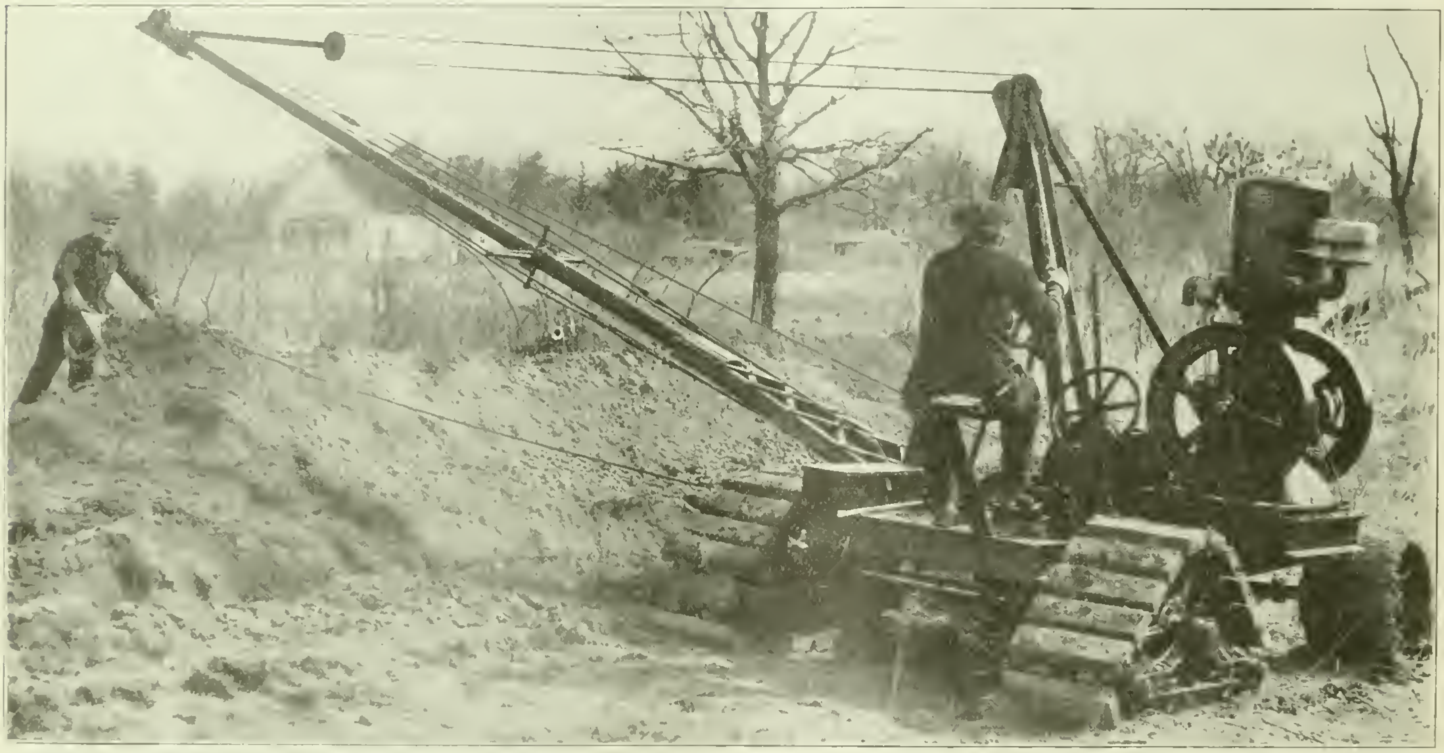
One of two concrete mixers, the largest ever constructed, is illustrated by the accompanying engraving. This mixer has a capacity of 160 cu. ft. of loose material or 108 cu. ft. or 4 cu. yd. of mixed concrete. No mixer exceeding in capacity, we believe, 2 cu. yd. has previously been constructed. These two giant mixers were called for by conditions arising in planning plant for a dam at Salisbury, N. C. The work called for the placing of 1,000,000 cu. yd. of concrete at the rate of 60,000 cu. yd. per month. Four 2-cu. yd. mixers would have met the output requirements, but limitations of space did not allow the lateral area required for a four mixer plant. It was then decided to ask mixer manufacturers to design and construct two 4-cu. yd. machines. The manufacturers finally selected were the T. L. Smith Co., Milwaukee, Wis., and the mixers planned and produced by them are represented by the illustration. In all general features the mixers are the double cone tilting mixers of the company named. The mixer body is mounted on steel skids and there is a fixed charging hopper carried by a steel frame. The mixer has a power tilting mechanism. The drum shell is ⅜-in. steel. The total weight is 23 tons. In the illustration the standing man furnishes a scale for judging the magnitude of the machine. It should be noted that the contractors for whom these mixers were built are the Hardaway Construction Co., of Washington, D. C.



Four Cubic Yard Concrete Mixer for Dam Construction at Salisbury, North Carolina.

A NEW POWER BACKFILLING SCRAPER WITH CATERPILLAR TRACTION.

Drag line scrapers for backfilling have within a few years become important earth-moving devices, and in the accompanying illustration we show one of the more recently developed power backfillers of the drag line type. This machine is of the board scraper type, is operated by a 10-HP. gasoline engine and has been designed with particular care in all features of the power unit. The notable special features are the special rolling traction mounting, the boom construction and the frame construction and machinery mounting to resist the overturning pull of the drag line. These three and other minor features are described by the maker as follows:



Drag Line Scraper Backfilling Machine With Caterpillar Traction.

The traction drive to the rear axle is by means of a No. 4103 pintle chain. The traction drive to the ground is either by means of a 30x18-in. wheel, or by the Parco Traction. The Parco Traction is made entirely of castings, making a firm and rigid construction. The caterpillar slats are of wood reinforced on top and bottom by means of steel plates. The dimensions of the traction are 18 in. wide and 4 ft. 6 in. long.

The main object in the design has been to arrange the machinery, etc., so as to have the center of gravity as low as possible in order to resist the pulling over action of the cables. The drag drum is mounted underneath the engine base and the cable pull is from the underside of the drum, giving the board scraper line an entrance into the machine underneath the main sills approximately about 18 in. above the ground level. This line is protected in bending and chaffing, etc., by means of a 4-in. diameter fair lead roller mounted horizontally and vertically in cast frame. The hoist drum is mounted on the engine base, but the pull is also from the under side.

Another feature is the housing into which the peak sheave is mounted. This housing is made so as to mount two rollers on the under side to prevent the cable from leaving the sheave in case of a side pull. This is an important feature of drag scraper work.

The boom is of pipe construction with exception of the lower end, which is of 4-in. channels forming a stiff leg span so as to gain the proper resisting strain to side pulls. The pipe construction allows the boom to be telescoped so as to lengthen out or shorten without dismantling the boom proper. Truss rods are provided on the four sides to resist strains that may come upon the boom and still have it of a light construction. The boom suspension line is controlled by hand-operated hoist on the main frame. The drag cable is ½ in. The hoist cable is 7/16-in. and the boom suspension cable ⅜ in.

The speed of the backfilling cable is 95 ft. per minute, and the hoisting speed 115 ft. per minute. The pull given to the backfilling line is approximately 3,500 lb. The speeds as given for the engine power allow the scraper to do about fifteen times the work of a horse outfit, at the rate of four loads a minute.

All the machinery is of cast steel construction, and the drag scraper is of heavy wood construction, reinforced with bars, and is 30 in. wide and 4 ft. long, provided with a bent handle made of pipe, so as to drag over the pile on the return pull. The weight in working order is approximately 4,800 lb. The manufacturers are The Parsons Co., Newton, Iowa.

METHODS OF FIXING CURB AND SIDEWALK GRADES AT STREET INTERSECTIONS ON STEEP GRADIENTS.

By John Wilson, Civil and Sanitary Engineer, Duluth, Minn.

The first attempt to formulate a method of establishing grades on steep gradient in Duluth, was by Andrew Rosewater and Rudolph Herring, consulting engineers who were employed by the city about 25 years ago. The method proposed by these engineers is the same that I am about to describe although slightly modified in some respects.

If the grade on any street is 2 per cent or less, Rosewater and Herring allowed, 3 per cent, the grade is carried across the intersection without breaking, if the grade exceeds 2 per cent but is not more than 8 per cent it is broken at the curb line and carried across the intersection on a 2 per cent grade. If the grade exceeds 8 per cent it is broken at both the curb and property line. In the business section the grade between the curb and property line is limited to 5 per cent in order to avoid the transverse slope of one sidewalk being toward the building or that of the other exceeding 10 per cent.

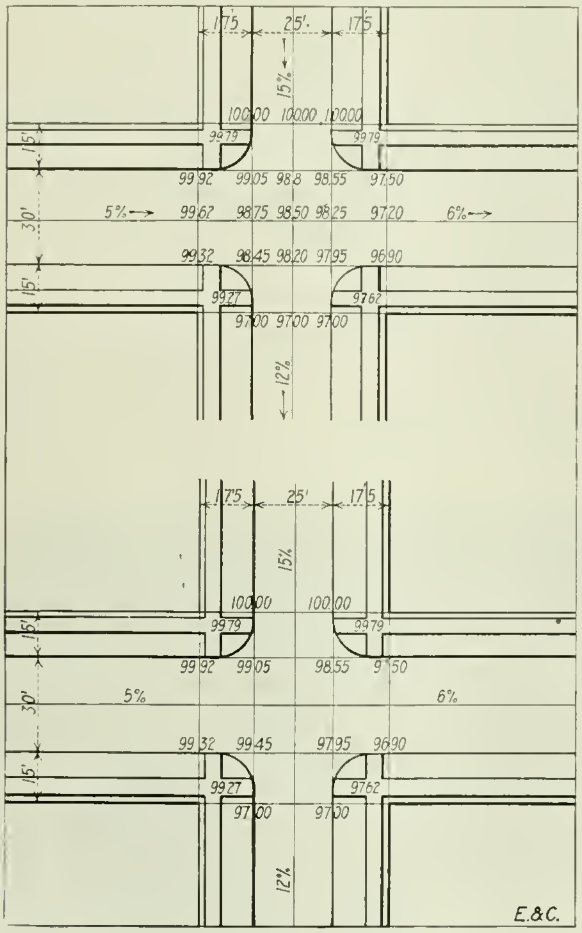
In the business district the elevation of the sidewalk at the building corner is determined by 2 per cent of the distance between the curb and building line to the eleva-

---

*Extract from a paper read at the annual meeting of the Minnesota Engineering Society.

tion of the curb opposite and then taking the mean between these two elevations, providing the elevation thus determined is not less than that of the higher curb. In the residence district there is no advantage in establishing the grade of the property corner.

As the elevation of the center of the street will depend upon the crown of the pavement selected, these elevations should be used only in determining the elevations of the curbs and should not appear on the established grade; unless the center line profile only is established, in which case the curb grades must be made to conform with the center grade and the character of the improvement. However, as sidewalks are usually the first improvement on a street, and the property owners improve their front to conform with the walk the first method is preferable, notwithstanding, the uncertainty in assuming a width of pavement.



Typical Computation of Curb and Sidewalk Grades at a Street Intersection on a Hillside.

The method of establishing the curb and sidewalk grades in the residence district is best explained by a typical case. Assume the intersecting streets are both 60 ft. wide, the distance between the curbs on the steeper street is to be 25 ft., while that of the other is to be 30 ft., this leaves a space of 17½ ft. between the curb and property line in the first case and one of 15 ft. in the second case.

The grades on each side of the street intersection of the street having the steeper grade, exceed 8 per cent and are therefore broken at both the property line and the curb line. The grades on the other street being less than 8 per cent but more than 2 per cent are broken at the curb line only. The center line grades of both streets are now computed. As the street having the steeper grade is practically at right angles to the contours, it will be an advantage to fix the elevations of the curbs on the two sides of the street at the same height. On the other street the cost of construction can be decreased and the improvement made to conform more nearly to the adjoining property by making one curb higher than the other.

The elevation of the curb on the steeper street is taken from the elevation of the center of the street opposite, while the elevation of the intersection of the property line extended and the curb on the other street is determined from the elevation of the intersection of the curb extended with the center line of the first street. We thus have a fall of two per cent across the hillside street or the street parallel with the contours.

If the pavement selected on the latter street has but little crown, or is of a slippery character, the curb on the upper side of the street is made 10 in. and the curb on the lower side 6 in. high. The crown of the street may also be placed at the third point instead of in the center.

The elevation of the intersection of the outer edge of the sidewalk is made an amount equal to 2 per cent of the width of the grass space higher than the elevation of the highest curb, and the discrepancy with the lower curb taken up in the grass plat.

In some cases on the lower side of the street the sidewalk is placed below the curb; this should not, however, be more than 8 per cent of the width of the grass plat in order to avoid the appearance of a sag in the walk. In other cases where the transverse slope of the walk at the intersection will be excessive by the use of the above method, the walk grade is broken at a point 25 ft. from the curb and is made to meet a mean elevation as in the case of a business district only that the elevation of the walk may be less than that of one of the curbs.

The drawing is a typical computation of the curb and sidewalk grades at a street intersection on a hillside.

SOME PROVISIONS OF THE REVISED NEW YORK BUILDING CODE.

On March 14, 1916, the final article of the revised New York building code became effective. As has been pointed out previously by this journal the revision has been made under the direction of Rudolph P. Miller, formerly superintendent of the building department of the borough of Manhattan. In revising and adopting this code an effective innovation was adopted, which consisted of adopting, successively, each section as it was completed, the sections becoming effective three months after enactment. The following is a summary of some of the principal provisions and changes:

Certificate of Occupancy.—The new code prohibits the occupancy of any building hereafter erected until a certificate has been issued by the Superintendent of Buildings certifying that the building as erected conforms with the approved plans and provisions of the law applying to that kind of building, and stating in what way the building may be used, whether for residence, business, or other purposes, what loads are permitted on the several floors, and the number of occupants there may be in each story.

In the case of an alteration, a similar certificate is required when the alteration is completed. This new provision will prevent a heretofore not uncommon practice of getting permits for buildings of a certain occupancy and then using them otherwise. But the certificates issued under this provision will also have a positive value to the owner. It will be prima facie evidence that his building is built according to the law. It should serve him well in case he wishes to make a transfer of the property. It should also serve him well when any question as to the legality of the building is raised.

Adoption of Rules.—The new code gives the Superintendent of Buildings authority to adopt rules with respect to the materials or mode of construction consistent with the provisions of the building code, as such may be necessary from time to time to secure the intent and purposes of the law. To safeguard the public against the arbitrary issuance of rules affecting construction, it is provided that no rules can become effective until they have been published for eight sucessive weeks in The City Record and a public hearing has been granted, if request for the same has been made during the period of publication.

Provision is made that where there is any doubt as to the classification of any building its status will be established by a rule issued by the Superintendent in the manner just described. Types of construction provided for are: fireproof, non-fireproof and frame.

Lighting, Ventilation and Exits.—Under the provisions of the new code every living room must have windows of certain size opening directly on a street or court of certain dimensions, depending on the building's height. Office buildings, if not lighted and ventilated as provided for residence buildings, must have other suitable means so that the air cannot be vitiated beyond a certain limit. Public buildings must have a positive system of ventilation.

The old code merely provided that in certain buildings, namely, stores, factories, hotels and lodging houses, staircases should be provided according to the area of the building. The new provisions base the requirements for the number of stairs partly on the area of the building, but more particularly on the number of occupants.

The owner may specify the number of occupants for which he requests a permit, but in case he does not state how many people he wishes to provide for he must design his exit facilities to provide for a certain number as indicated in the article, dependent on the character of occupancy. Having applied either method of determining the number of occupants, the use of that building is thereafter restricted to the number of occupants for which exit facilities have been provided.

Fire Towers.—A new provision requires that buildings exceeding 85 ft. in height, which is the limit within which the fire department can cope with fires from the street, shall have at least one fire tower. (By fire tower is meant a fireproof enclosed form of staircase.)

The intent of this provision for at least one fire tower in tall buildings is to secure to the fire department a means of reaching a fire above the ordinary limits of its apparatus, and giving it a safe line of retreat in case such fires should get below the story on which it originated.

Projections Beyond Building Line.—Article 9 of the new code deals with projections beyond the building line, enumerating those things which are permitted and the conditions under which they may be used. The permissible projections include areas which are covered over with gratings, steps to the extent of 18 in., ornamental porjections, such as columns and pilasters, etc., to the extent of 18 in., balustrades of an ornamental character to the extent of 22 in., mouldings, sills and similar decorations to the extent of 10 in., main cornices to the extent of 5 ft., base courses to the extent of 10 in., rustications to the extent of 4 in., awnings and marquises occupying a limited part of the street frontage, fire escapes, vaults up to the curb line, hose connections and fresh air inlets to the extent of 12 in. All such projections, however, must be so constructed that they are easily removed in case the city finds it necessary to utilize the space for its own purposes.

Concrete and Hollow Tile Construction.—The new code describes the conditions under which concrete piles are permitted and gives the loads which may be placed on them. While hollow tile and concrete building blocks had been heretofore used to a limited extent in one or two-family residence buildings, under rules issued by the superintendents, their use is now recognized and provided for in the law. While the limitations placed on the use of hollow tile for outside walls practically restricted it to residence buildings, it is permitted to use hollow tile blocks in part in the walls of buildings of skeleton construction. When used in this latter way a brick veneering is required on the outside.

Reinforced concrete is now also provided for in the code. Heretofore its use was controlled entirely by rules promulgated by the superintendents, with the possibility of changes in these rules without restriction and without notice.

Both cinder concrete and terra cotta floor constructions are permitted under conditions which are fair to both types of construction.

In the old code no provision was made for cinder concrete construction as it was generally practiced, except a provision permitting its use if floor and load tests were made showing its sufficiency. This necessitated a large expenditure for tests on the part of those who developed different systems. Under the new code general provisions are made governing the construction of cinder concrete floors, based on the experience heretofore gained by these tests.

Chimneys and Elevators.—A provision of the new code requires that the owner of a new building, which exceeds in height an adjoining one, must carry up the flues and chimneys of the lower building so as not to deprive the owner of the lower building of proper draft.

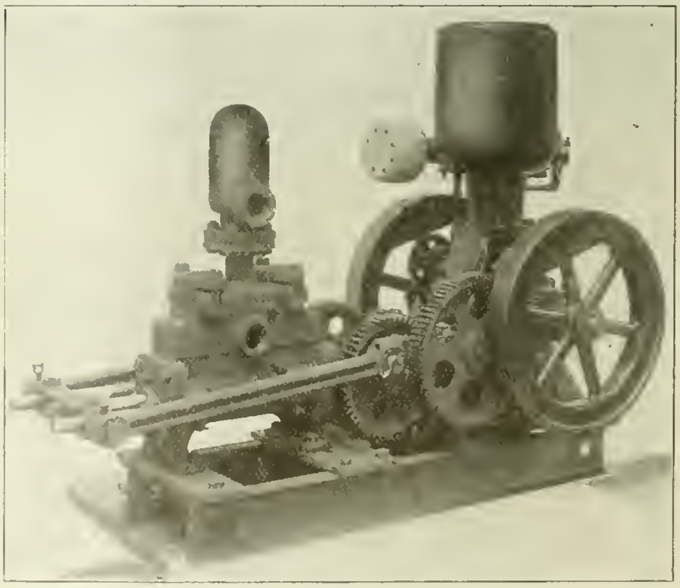
Under the revised code it will be unlawful to operate an elevator hereafter installed until the Superintendent has issued a certificate stating that such elevator is safe. Such certificate must be posted in the car and new certificates are to be issued after each periodic inspection.

Penalties.—The new code provides that the penalty for a violation of the code shall not be less than $10 nor more than $50, and for a continuance of violation not less than $50 nor more than $250.

To compel the immediate compliance with an order relative to a violation affecting the public peace or safety, the new code makes such a violation a misdemeanor in case any person shall fail to comply with any written peremptory order of the Superintendent of Buildings within the time specified.

A NEW PRESSURE PUMP FOR WATER SUPPLY FOR CONCRETE ROAD CONSTRUCTION.

Water has been pumped as far as 16 miles for concrete road construction. Water for concrete road construction has been pumped against a static head of 200 ft. The volume of water required for concrete road construction varies from 100 to 250 gal. per cubic yard of concrete pavement laid. A pump for road construction water supply must be strong, compact and powerful; it must be light and be mounted so as to be easily transportable and cheaply installed and removed. In light of these facts the pump illustrated, designed specifically for road construction water supply is worthy of notice. It is a pump designed for long distance delivery, for high lifts, for high pressures and for severe conditions.



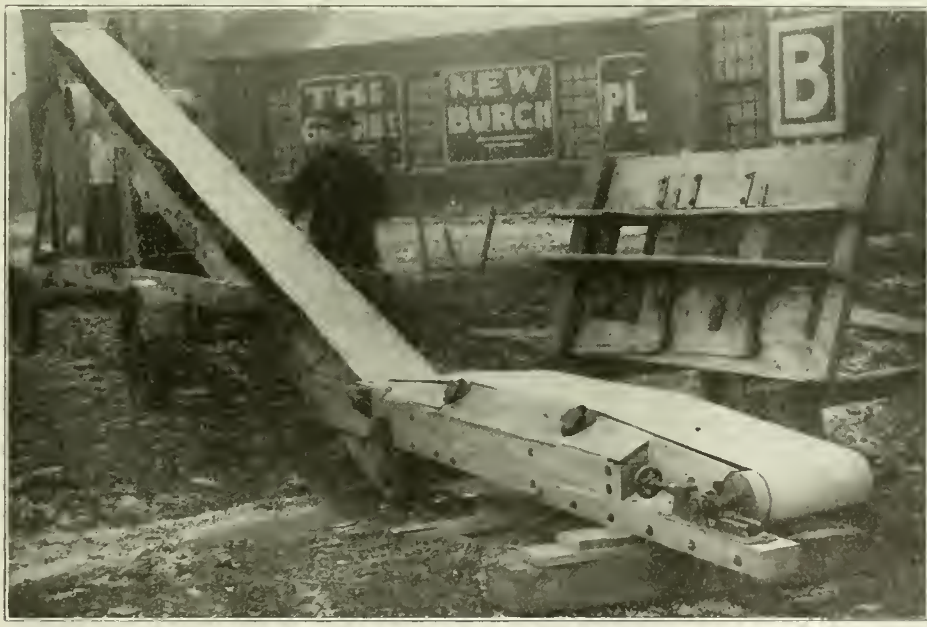
High Pressure Pumping Outfit for Water Supply for Road Construction.

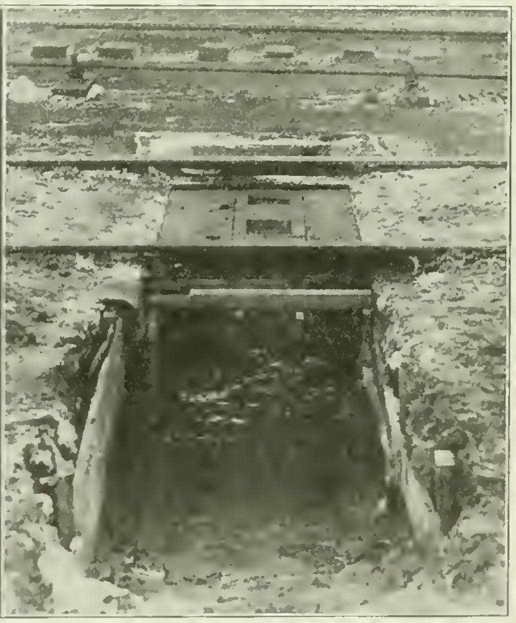
Cataloging of special materials and mechanical niceties of construction cannot be given space. In both material and workmanship, however, the pump is excellent. Mention of general and special features is essential. First to be noticed is the all metal construction, including skids, and the compact arrangement and rigid mounting. The base casting, also, unites in one piece the shaft bearings and the pump seat and so insures perfect alignment of gears. Another feature is the double drive for the pump piston, and the cross-head guides. This arrangement gives an even distribution of power to the pump. Any part of the pump can be removed for repairs without dismantling the machine and, it is stated, in five minutes' time.

The pump is made in four sizes from 1½ h.p. to 4 h.p., and from 900 gal. to 1,400 gal. capacity per minute. The weights range from 525 lb. to 915 lb. The makers are the Barnes Mfg. Co., Mansfield, Ohio.

A CONVEYOR FOR UNLOADING FROM CARS INTO WAGONS.

The device illustrated has had successful practical use in the unloading of broken stone and similar materials from bottom discharging railway cars into wagons or motor trucks. It consists of a platform with trap doors which is set under the track as shown. Material falling through the trap doors is taken by belt conveyor to the top of the incline and there drops into the wagons. The mechanism and carriage are made clear by the illustrations. The belt conveyor is 16 in. wide and is operated by a 4-h.p. gasoline engine. When moving the belt is removed and rolled up and the tail of the conveyor frame is unhinged and with the trap platform is loaded into the carriage. Also the inclined frame is disconnected from the standards at the higher end and lowered to a nearly horizontal position. Loaded as described the whole outfit is hauled on the carriage. This loading conveyor is made by the Burch Plow Works Co., of Crestline, Ohio. The company is now developing a similar device for unloading from car into storage bins.





Conveyor for Unloading From Hopper Bottom Cars Into Wagons.

THE ELECTRIC PUMPING OF DEEP WELLS AT MEMPHIS, TENN.

(Contributed.)

The pumping of deep wells for a water supply, where a large volume of water is necessary, has always been considered a serious problem. In the spring of 1910 the Water Department of Memphis, Tenn., in an attempt to solve this problem, decided to try the "Wills Pumping System." (Patented March 14, 1916. Wirt J. Wills, patentee and manufacturer, Memphis, Tenn.) This attempt was successful. Mr. Wills is and for years has been the general superintendent of the Memphis Artesian Water Department.

The first unit of this system that was installed proved so successful that 14 more were added. These are located in the suburbs within an area ten miles across. These units were placed in wells which are segregated sufficiently to prevent the flow of one from interfering with another. This segregation of wells has proved a great success, having been in operation now for six years. With this system large distributing mains are unnecessary, the pressure is increased where it is needed, friction is reduced to a minimum, and the supply is conserved by not drawing on one area beyond its capacity.

The size of the wells used in Memphis is 10 in., though as small as 6 and as large as 18 in. might be used, depending on the quantity of ground water present. The pumps being electrically driven, the area covered can be made to suit conditions. Should the ground water recede, at certain seasons of the year, it is only an hour's work to screw on another section of the lifting element, thereby keeping within reach of the water.

Water pumped from segregated wells is much cooler and retains its natural gas more than water which has to travel long distances in mains.

The pumping units are installed in concrete pits under the street, thereby saving the purchase of real estate, nothing being visible on the street except the manhole. The electric controllers, indicating the rise of pressure, hot bearings, or fluctuations in current, instantly stop the pump and show on the indicator which is placed in a central station or in each pit. If the pumps are not operated from a central station, one man on a motorcycle can easily care for from six to eight, as his only duty is to see that they are kept properly lubricated.

Any combination pump composed of a rotating element placed in the wall, lifting the water from the well below the suction limit, working in conjunction with a force pump on or near the surface and of the same capacity as the well pump, which lifts the water from the well and forces it against a head above the surface in a continuous and uninterrupted flow, is the "Wills Pumping System."

In Memphis two forms of the pumping device have been used, differing only in the forcing element. In one arrangement there is used a rotary force pump, and in the other arrangement a centrifugal force pump, but in both arrangements the rotating well pump is used, working in conjunction with the force pump on the surface.

The lifting element of the pump which goes down in the well is composed of a shaft on which is mounted impellers so proportioned that the amount of water lifted is the exact amount which the force pump discharges against the head. The shaft and these impellers are placed in a steel casing made in sections of different lengths, which are coupled together by an ingenious deflector guide. This deflector guide not only rids the water of the whirling motion before it reaches the impellers, but catches the water which falls, enabling the weight of same to be carried on the steel casing instead of the shaft, and its internal bearings are such that the shaft never touches them except when swerving in a periphery motion, at which time the bearings guide it straight. Being continually in the water, these bearings require no lubricating; in fact, all the lubrication about the entire device is above the ground and easy of accomplishment.

In the combination with the rotary force element the water is lifted from the well to the inlet pipe of the rotary pump, the well pump, the rotary pump and an electric motor being synchronized in movement. In the centrifugal combination the same well pump elements are used, but the water is lifted into the eye of the vertical centrifugal force pump, the well pump and the force pump being operated synchronously with a motor which is on the top of the centrifugal.

The total head that the Memphis pumps have to pump against varies from 190 to 270 ft., but almost any head can be pumped against, more power, of course, being required for a high than a low head.

During the six years of operation in Memphis improvements in mechanism have been made, and the efficiency of the entire outfit has been very materially increased during the last year. The efficiency over all is 51 per cent and on larger sizes it is about 20 per cent more.

While this pumping system is especially good for large cities, it is also very economical and practical for a small plant. Where the electrical plant and the water works are combined it makes an ideal combination, pumping the water in the daytime and furnishing current at night. The cost of this system for installation is about one-third that of others, the cost of operation is low and the maintenance is very low, since all the wearing parts are above the ground.

During the drouth of 1914, when almost every city in this country suffered from lack of water, the Mayor of Memphis advised the citizens "to use all the water they wanted for sprinkling flowers, garden and lawns or any other purpose." There are many cities with an inadequate water supply that with small expense could enjoy an abundant supply of water should they adopt this system.

THE CAUSE, AMOUNT AND RESTRICTION OF INFILTRATION OF GROUND WATER INTO SEWERS.*

By Charles P. Chase, Manager, Iowa Engineering Co., Clinton, Iowa.

On investigation we find that the infiltration of ground water into sewers is the most important item in sanitary sewer construction; it makes up from 30 to 60 per cent of the flow; it may be the most costly difficulty to overcome, and it provides a means for the dissemination of disease.

In the past, combined sewers were generally constructed, and ground water was considered a benefit, accomplishing a sort of disposal by dilution, and at the same time its admittance to the sewers drained the ground, dried cellars, and furnished a medium of flushing and transportation.

The demands of sanitary sewerage and the imperative necessity for the treatment of sewage have changed all this. If ground water leaks in, sewage can get out, and sewage has been known to travel many miles underground, retaining pollution and disease germs.

The admission of ground water greatly increases the cost of construction, operation and maintenance, requiring larger sewers and disposal works; and if in a situation demanding pumping an additional large increase of yearly expense to lift this unnecessary burden of water; so in a sanitary system leakage should be cut to the lowest possible amount.

Let us inquire as to how infiltration occurs. The ordinary sanitary sewer is constructed of vitrified, or at least hard-burned clay, and in first-class material is covered with a salt glaze. Such a pipe is impervious to water, so we must look further for the leaks, and we find them in cracked pipe, poor joints, poor manholes, joints opened by settlement, and last but not least faulty house connections.

It has frequently been observed that a first-class job on the main sewers, under excellent plans, competent contractors, and firm and thorough engineering inspection, has been greatly impaired by the haphazard and negligent manner of making subsequent house connections.

So far, most attempts at tight sewers have not been a success.

It has been claimed by eminent authority that when a pipe line is laid with the utmost care and every joint perfect, the nearby wells became dry down to the flow line of the pipe. That such is the almost universal result the writer knows to be true, after a quarter century of sewer building in a hundred different localities, but is this necessarily pipe or sewer leakage that dries the ground and wells? In sewer trenches the ground is frequently a succession of clay dikes of a more or less impervious character, crossing sand pockets, soils, and other strata, or it may be rock. These dikes hold back the water and when cut through release the flow which will follow the line of least resistance, now the trench, whether piped or not.

In one instance in the construction of a large system just cutting into the top layers of underlying rock, frequently after cutting through a new rock dike, the water would come in such quantities that it was almost impossible to work until drained down. In one case a centrifugal pump ran 30 days at the rate of about 4,000,000 gal. per day before the water level was reduced sufficiently to allow the construction to proceed. The water came in on all sides and from the bottom, then followed along the new channel, the level of the ground water being lowered 10 ft. by the cutting of an 8-ft. trench, 15 to 17 ft. deep, before a foot of sewer was built. In other systems it has frequently been observed that a ditch, which when first opened only appeared damp, by the next morning had accumulated several feet of water, and the longer the trench was opened, at least for several days, the more the amount of water would increase, and then gradually begin to decrease.

It has also been observed that when there was practically no water flowing inside the pipe in a dry pipe line, water has been found running outside of a pipe, and even standing over it, so we can but conclude that the mere opening of the trenches in most cases accomplishes drainage to the grade line. Another effect of water running outside of the pipe line was where, after a personal observation it was known that every joint was perfectly made, the inspector in one particular case having felt over each joint with his hands all around; then the joints were covered with dry earth and well packed, and several years afterwards some of this line broke down by the sandy soil in which it was laid, moving and washing along the outside of the pipe line to such an extent that the line was let down, breaking the pipe, opening the joints, and the pipe in some cases settling so that when dug up for repairs they were found 1 in. apart. Also instances were found where the cement was all gone from joints known to have been perfect, and only the oakum left, showing that the water on the outside washed the cement away before it had thoroughly set.

Another source of leakage is the breaking open of joints by the settlement of the backfilling, generally when settled suddenly by a storm or flushing before the cement is sufficiently hardened to hold the pipe in place.

The collapsing of the side banks on the removal of sheeting, or even where no sheeting is used, frequently not only opens joints, but may crush the pipe like a nutcracker. Again, cracks occur which are almost unexplainable. The writer once laid 1,000 ft. of excellent double strength 36-in. pipe in 10-ft. trench, and 10 years later had occasion to take it up, and found one huge crack the whole length.

It is generally conceded that it is next to impossible to secure tight work in quicksand, water-bearing sand, or soft muck under ordinary conditions with the materials used. If the cement is covered, the water bores it out; if left to harden before covering, the weight of the shifting sand cracks the joint open.

---

*Paper before Iowa Engineering Society

The writer secured some very good results on one wet job in sand by using a mortar of one part Portland cement to one part of sand as stiff as could be worked, using this on top of well calked oakum joints, and then burying the joint by plastering over it with a waterproof, putty-like blue clay found on the job. This was gathered by the wagon load, and a man prepared it for use.

When the trenching is in clay and care is used, fairly tight work can be secured, but the clay must be packed tightly under and around the pipe. With the new trenching machines, which move so rapidly, it is found difficult to secure this proper tamping around the pipe, especially when the automatic back-filler is used, but it can be done.

The use of sub-drains and tile is frequently advocated to take care of ground water and to secure tight work in the sewers, but it is a myth and failure. In Massachusetts, where it was extensively used, the drain water was almost as polluted as the sewage; in other words, the leakage from the sewers descended to the drains. It is almost impossible to keep the drains open for any considerable distance in quicksand or sandy soils where there is much water, as the sand will go wherever the water will, and unless the grade is considerable choking occurs, also extra width must be allowed, extra depth taken out, and extra strong sheeting used to hold the banks, and for the much greater time the trench must remain open, there is extra hazard and danger where frequently every minute counts.

Having now enumerated the principal causes of leakage and reviewed the difficulties encountered in trying to overcome them, and granted that we wish to prevent the infiltration of ground water, we are ready to consider the question of how to secure tight work. The writer believes that in ordinary soils and under ordinary conditions, that practically tight work can be secured by carefully made cement joints, and that where this can be done a great deal of money can be saved in construction.

In order to secure tight work, then, we must first have the best quality of vitrified, salt-glazed sewer pipe, without cracks or breaks, and laid to a true line and grade in such a manner as to give the pipe a firm bearing on the soil beneath. The joint is first to be carefully and fully calked with a gasket of oakum, soaked in neat cement of about the consistency of cream, and as carefully packed as for water pipe, although of course it cannot be driven up with hammer and calking tool as forcibly as for iron pipe without the danger of breaking the pipe, The joint is then to be filled with a mortar composed of one part of Portland cement to one part of sand, seeing that all parts of the joint, particularly underneath, are thoroughly filled and the mortar is brought to a slight bevel outside by a laborer wearing rubber mittens. A trowel may do the work on top, but it won't do the work underneath except on very large pipe, and the only way the inspector can tell that the joint is perfect is to pass his hands over it himself. All water must be kept away from the joint until set, this to be accomplished either by allowing the joints to stand uncovered, or else by covering the cement over with a plastic waterproof clay, or otherwise packing clay tightly around the pipes and joints. Ordinary soil will not keep the water back if there is much of it, and sod, straw or such material sometimes used is worse than the water or mud itself. In wet sand or quicksand, support the pipe on boards or timbers and keep the water drawn down with pumps until the cement is set, when it may be carefully covered, making sure to pack the soil firmly around and over the pipe; or in more extreme cases the pipe may be buried in rich concrete, or a ring of mortar 5 or 6 in. thick placed around the joint and secured by a band of cloth or other device until set. The greatest objection to the use of cement in making joints is the possibility of its being knocked out of the joint before it has begun to set and becomes thoroughly hard, washed out by water, or the joint broken open or disturbed by future movements of the pipe after it is laid. To overcome the objections to cement I have used at various times joint mixtures of sulphur compounds, tar compounds and asphalt, but not with much success. The sulphur compounds fequently became too hard and cracked open, and were inferior to cement, and the tar and asphalt compounds disintegrated or dissolved in a few years. Within the past few years there has come onto the market some very much improved compounds for pipe joints, and although they have not been in use for a sufficient length of time to determine absolutely their life, permanency and usefulness, some quite satisfactory results have been reported in a number of cases, and the parties who are manufacturing them make very broad claims which, if substantiated, would seem to solve the question of tight joints. However, as in most cases, we hear some adverse reports and find some contractors very much averse to their use.

These jointing compounds are generally used hot and poured into the joint, similar to the lead joint of water pipe, which of course means that first, the calking must be absolutely tight or the jointing material will go through inside the pipe, and, second, the use of a tight gasket around the joint and the exclusion of all water when the jointing is poured, or else the joint is likely to blow up or leave imperfections; also, if mud or sand gets in the bell the joint is spoiled. In a bad ditch this is omnipresent, and from my own experience I know that it must be carefully handled and is a much slower process than the cement joint. Moreover, we all know that the speed with which the pipe is laid often solves the question of getting out of a bad place.

But, on the other hand, if we must have this tight work, it means that the trenches must necessarily be widened, that more sheeting must be employed, and we must be content with a slower progress, and the balance between perfectly tight work or work in which some infiltration may occur will have to be figured out by the engineer, and which to some extent, of course, overlooks the sanitary feature of a possible leakage outward from a sewer that will let anything in.

We now have remaining the question of a standard of leakage or infiltration, or whatever we have a mind to term it; that is, the amount of water that will get into a pipe line when practically every possible means for excluding it was taken under varying conditions. On an examination of the records of measurements of infiltration in sewer systems already constructed, we find that in terms of the flow it is reported as all the way from 5 to 40 per cent of the normal flow of the sewer, or of leakage in gallons per mile of systems already constructed, running from 5,000 gal. per mile to as high as 80,000 gal. per mile in pipe sewers, and even more in some exceptional cases. A minimum of 5,000 gal. per mile has been suggested by several of our engineers and technical journals, but the writer believes that this is almost impossible to attain except under the most favorable conditions and in the most favorable soil, and that the adoption of so high a standard would be impractical to carry out.

An example of practical results is given by Mr. E. C. Rich, who observed and examined the construction of an 18-in. pipe line in a 13-ft. trench where he knew absolutely that every joint was made perfect, and after the backfilling was all put in and the line completed it was found that the pipe line leaked some at every joint, and in one place a stream as large as a lead pencil was running in.

The writer constructed one sewer system of 10 miles under adverse conditions, where there was a great deal of water and the pipe lines were all below the water line. After a fairly dry season and the work was all completed we found about 40,000 gal. leakage in the system or 4,000 gal. per mile. In this I believe I am warranted in stating that practically every joint was perfect when made, as the supervision was very thorough and strict and every joint was watched, but in the spring of the following year the leakage ran up to about 200,000 gal. for a period of a week, and this has been about the variation in this system ever since constructed. It has been in use 20 years, has never had a stoppage, and is regarded by the corporation as a perfect piece of work, but the leakage is there.

From my own observations, I would not be willing to attempt to guarantee a leakage of less than 10,000 gal. per mile in ordinary soils, and 20,000 gal. in water-bearing sand or quicksand; 20,000 gal. per mile being about the basis that I have usually figured on.

METHODS AND COSTS OF CONCRETE LINING IRRIGATION LATERALS, ORLAND PROJECT, U. S. RECLAMATION SERVICE.*

By A. N. Burch, Project Manager, Orland.

To February, 1916, there had been lined about 22 miles of laterals on the Orland project, in sections ranging from a few feet in length and requiring less than a cubic yard of concrete to a maximum section of 8,800 ft. The cross sections of the laterals lined have ranged from a bottom width of 2 ft. and vertical depth of 1 ft. to a bottom width of 8 ft. and vertical depth of 4½ ft.

Laterals originally designed for lining were built with 1:1 bank slopes; other laterals with 1½:1 and 2:1 slopes. On the distribution system covering the 6,000 acres recently taken into the project all laterals were designed for lining, where a reduction of cross sections and the elimination of drops would justify this course, as compared with building a larger earth section and installing the necessary drops to reduce the grade.

On the project generally, lining has been placed in all fills; in the small laterals acquired from the old Stony Creek company and located within highway boundaries, for the purpose of increasing their carrying capacity and reducing maintenance; in sections where seepage was excessive; as a protection over storm culverts and on curves; also at forks of laterals where, because of the number of structures, it was difficult to clean with teams.

For the longer stretches of the work a 4-cu. ft. mixer, driven by a 3-h.p. gas engine, all mounted on trucks, is used; for the short stretches small hand-mixing crews are employed. The aggregates used are run of bank material obtained from creeks in the vicinity of Orland. The proportions of mix are approximately 1:3:5, giving 1 cu. yd. of concrete in place of 1.1 bbl. of cement.

The mixer crew is made up of a foreman, with about 30 men and 2 teams. Nine men are employed at the mixer in wheeling and in placing and finishing, and from 18 to 20 men in trimming the slopes and preparing the bottom for receiving the lining. One team is employed in hauling cement and one in hauling water and miscellaneous work. When it is possible to do so, water is run in the laterals and kept close behind the lining crew, thus reducing the distance of haul to the mixer and simplifying the process of wetting the completed work. No special tools are used in preparing the slopes and bottom for lining, the work being done with mattocks, picks, and square-ended shovels.

The mixer is usually set up at the side of the lateral in the center of a 500-ft. section, making the maximum wheel for concrete 250 ft., which was found to be about the greatest economical distance to which the material could be wheeled. As most of the lining is placed in fills, trenches are cut through the ditch banks to admit of a wheeling plank, which, when placed, lands on a small turning platform, from which an incline leads to the bottom of the lateral, and to additional boards on which the material is wheeled to the placers. End-dump barrows are used, and the material is dumped into a mud box, from which it is shoveled to the slopes.

The mixing crew is made up of one mixer operator, two shovelers for charging the mixer, three wheelers, and three placers and finishers. Of the latter, No. 1 places the concrete to the required thickness (being guided by a templet), No. 2 compacts the material and finishes it roughly with a square-ended shovel, and No. 3 gives the final finish with a 5 by 18-in. long-handled Arrowsmith trowel, finally cutting the expansion joints with a straight-edge and pointing trowel and smoothing them up with a grooving tool. Before placing the lining the slopes are thoroughly wet by means of a force pump attached to a water wagon, and the finished lining is kept wet from 3 to 5 days, depending on weather conditions. The average daily output of the mixer force is 25 cu. yd., and the maximum 30.3 cu. yd.

For short stretches of lining hand-mixing forces of about 12 men each are employed. From 5 to 7 men are employed in mixing and placing, and about an equal number in preparing the slopes and bottom for receiving the lining. The same equipment and about the same arrangement are used in the operation of these crews as is the case with the mixer, except that the mixing board is placed on timbers which span the lateral, the aggregates are wheeled on to the board, and the concrete shoveled into barrows in the bottom of the ditch, there being no incline over which to wheel the material. These gangs average about 12 cu. yd. per day, and when there has been a full day's run without any long moves have made 15 cu. yd.

There is little difference in the cost of lining whether the material be hand or machine mixed, although the machine turns out a better and more uniform grade of concrete.

From October to June climatic conditions on the Orland project are very favorable for this kind of work, as there are no temperatures low enough to affect the concrete adversely, and moisture conditions are usually such that the lining can be cured properly with little expense for wetting. During the summer months moisture conditions are reversed, and because of the thinness of the lining it is necessary to wet it from two to four times per day until it is properly set. Following are unit costs and related data:

COST PER SQUARE YARD.

Cement delivered on work	$0.0957
Gravel delivered on work	.0408
Mixing concrete	.0314
Placing concrete	.0294
Sprinkling and protecting	.0046
Preparing section for lining	.0697
Field superintendence and engineering	.0010
Maintenance of equipment	.0022
Plant arbitrary	.0043
Total labor and material	$0.2791
General expense	.0639
Total cost to United States	$0.3430

Thickness of lining, 1½ inches. Total placed in square yards, 191,400. Total in cubic yards, 7,900. Cost per cubic yard, $8.26. Average haul (round trip), gravel, 5 miles. Average haul (round trip), cement, 6 miles. Foreman, $3.20 per day to $95 per month. Finishers, $3 to $3.20 per day. Laborers, $2.40 to $2.60 per day. Teamsters, with teams, $4.50 to $5 per day. Cement, $2 per barrel. Gravel, $1 per cubic yard. Lumber, $14 to $22 per M. B. M.

PATROL SYSTEM, GANG SYSTEM AND COMBINATION PATROL AND GANG SYSTEM OF ROAD MAINTENANCE IN MARYLAND.

By H. G. Shirley, Chief Engineer, Maryland State Road Commission.

Where the patrol system is used, the patrolman has charge of from 4 to 8 miles of road, the length of section depending on the type of construction and the amount and intensity of traffic. Near cities or towns where the traffic is heavy, the patrolman's section is shorter and comprises about 4 miles of road, whereas in sparsely settled sections he can take care of from 5 to 8 miles of road.

The patrolman is supplied with the necessary small tools, namely, a mattock, pick, shovel, steel wheelbarrow, a concrete rammer, scythe, tar pot, red flag, and a cap on which is written in gilt letters "State Patrolman." He is also furnished with a number which he wears on his left arm, and by which he is known and which makes it possible for the traveling public or those living in the community to report to the State Roads Commission that patrolman number so and so is not making the proper repairs adjacent to their respective properties, is not on his job, or is not attending strictly to his duties.

---

*Extract from an article in the "Reclamation Record," April, 1916.

It is the patrolman's duty to carry out the following instructions, which are furnished him in printed form:

FIRST: Patrolmen will be furnished with tools, a cap, a number, and a red flag, as well as daily report cards, payrolls, and traffic reports.

The cap and number are to be worn by the patrolmen at all times when on duty, the number being placed on the left arm.

The flag is to be set up on the roadside so as to be seen from the road at the point where the patrolmen is working whenever he is on duty.

SECOND: Patrolmen are to work .... hours per day, being at the place they are to begin work at .... a. m. They must work every week day, weather permitting.

Patrolmen are to walk over the entire length of their section to repair anything needing immediate attention at least twice a week and after each heavy rain or snowstorm. A trip made after a rain may count as one trip in any one week.

THIRD: Patrolmen are expected to keep all ditches, culverts and underdrain inlets and outlets open at all times. The shoulders are to be kept to the proper grade and any washouts or large wheel ruts are to be filled immediately, keeping the shoulder in good line. All grass is to be kept close cut on the shoulder and slopes.

FOURTH: Patrolmen shall pay particular attention to the surfacing on their roads and patch any places which become bare or loose. These patches shall be made as instructed by the resident engineer, whom the patrolman shall notify when patching is required.

FIFTH: A daily report card is to be made up, using pen and ink, and mailed each day, showing the date, the name of the patrolman and helpers, if any, the number of hours made by each and the station number of the culvert near which the work was done, all in their proper space on the card.

At the end of each day the patrolmen shall enter upon the expense sheet or payroll supplied for this purpose the time for themselves and any other help or teams with which they may be furnished. On the nights of the 15th and the 1st of each month they shall forward to the office of the resident engineer their expense sheet, made out as explained for the one-half month immediately preceding. At no time shall the patrolmen engage help or teams without having first received the permission of the resident engineer.

At least once each month the patrolmen shall take an accurate account of the traffic of all kinds passing over the road in their charge and shall enter this information on the blanks furnished for this purpose and mail same to the office of the resident engineer.

SIXTH: Whenever a traction engine having sharp cleats passes over the road, the patrolman shall report it by letter to the resident engineer, giving the name of the owner of traction engine, the day and the hour on which the engine was seen on the road, as well as the name of any witnesses seeing the engine on the road. The patrolman should also report the point at which the engine came onto the road and where it left.

SEVENTH: If any person or corporation digs or places any obstructions whatsoever on the section of road under their charge, including the piling of lumber within the limits of the roadway as well as the placing of obstructions in culverts or waterways, the placing or removing of any structures, such as gas mains, water mains, telephone poles, track structures, fences, etc., the patrolman will ask the parties to show their permits from the State Roads Commission for doing the work. Should no permit be produced the patrolman shall notify the parties to discontinue work. Should the work not be immediately discontinued, the patrolman shall at once swear out a warrant for the parties trespassing and demand of the magistrate the immediate arrest of the parties for violation of "Laws of Maryland, Chapter 141, Section 32-E, Acts of 1908." In any case the resident engineer shall be notified as promptly as possible by calling phone No. .....

TENTH: In no case shall the patrolman contract or pay any State Road Commission's bills. Should it be necessary to purchase any material, tools, etc., the patrolman will write to the resident engineer and secure a written order for same. All bills must be made out to the State Roads Commission.

ELEVENTH: If at any time any patrolman is found turning in time on his reports in excess of what he actually spent on his road he will be immediately removed from the work. In case of dismissal or resignation of any patrolman, he shall immediately turn over to the resident engineer all supplies, tools, materials, etc., furnished him by the State Roads Commission. For all material, tools, supplies, etc., not returned and for which a good account cannot be given, an amount of money equal in value to the missing articles shall be deducted from any wages due the patrolman at the time of his dismissal.

TWELFTH: Patrolman shall act at all times under instructions given by the resident engineer.

The patrolman places the red flag on the section of road on which he is working, and when the resident engineer or inspector who passes over the road sees the flag he knows that the patrolman is at work in that vicinity. However, if he does not see the flag or the patrolman, he (the patrolman) is not allowed for that day's work. Also, if the patrolman finds it necessary to leave the road for any purpose he places the flag at the point at which he left the road, and when the inspector or resident engineer sees the red flag at this point he knows that the patrolman is somewhere in that vicinity and credits him with that day's work.

The following method is pursued in the selection of patrolmen: While the road is being built the resident engineer instructs the inspector to carefully observe the men working for the contractor, and if he sees any man, who lives in that vicinity, who is industrious and painstaking and who seems to understand road building pretty well, just before the contract is completed he is offered the position of patrolman to take care of that section of road when it is completed and turned over to the State Roads Commission for maintenance.

In this way it is possible for us to secure men who understand the conditions under which the road was built, and who are more competent in every way. The patrolman reports to the resident engineer and the resident engineer reports direct to the chief engineer.

The daily report cards with which the patrolmen are supplied inform the resident engineers whether their patrolmen are repairing the shoulders, opening the drains or making patches on macadam or concrete surfaces.

To enable the patrolman to make bituminous patches he is supplied with stone chips and bituminous patching material at convenient points, so that with the aid of a wheelbarrow he is in a position to transport material without any unnecessary delay from the stock piles to any abrasion or hole that occurs in the surfacing, and in this way no time is lost due to lack of material, long hauls, etc., in making the necessary repairs.

It is difficult to teach patrolmen just how to make patches to the surface where the holes are deeper than 1-in. or 2-in., for they either apply too much bituminous material, which causes a pushing about and a "hump," or they will not apply a sufficient amount, and there is immediate disintegration.

The patrolman is instructed to make a patch as follows: First, to sweep the hole thoroughly clean, free from all dirt and dust; paint the cavity with bituminous material; tamp the stone in well with a tamper, then spread bituminous material over the stone and apply stone chips from ½ in. to ¾ in. in size, just bringing the surface of the patch up to the same elevation as the adjoining surface of the road. It has been found that quite a number of patrolmen can make these patches without a great deal of trouble and get the proper amount of oil in so that the patch will be permanent and not push about, but there are many instances where they either get too much bituminous material in and it pushes about and makes a hump, or do not put sufficient in, and the consequence is "ravelling." To aid them, therefore, in getting just the proper amount of bituminous material in the patch, the patrolman should be supplied with a small wire basket, holding about ¼ peck of stone. This basket has handles, and it is only necessary for him to dip the basket with the stone in it in the bituminous material and then raise it and allow it to drain. By the time he has the hole thoroughly swept out and is ready to apply the stone the excess bituminous material has drained off, and it is only necessary to dump the stone from the basket into the hole, tamp it and cover with stone chips.

The question of politics should be absolutely eliminated, and the patrolmen should be made to understand that they will hold their positions as patrolmen on the road only through merit, and that if they do not render satisfactory services they will be dismissed. I know of no class of men who are affected more by politics than the patrolmen. They seem to believe that if they are put on the road by a politician or by political influence they have a perfect right to do as they please and give the state as little as possible for the wage received. We, therefore, allow the resident engineer to make all appointments and hold him absolutely responsible for the work of his patrolmen.

We also have in our system what is known as an inspecting engineer of maintenance who makes it his business to constantly go over all the roads being maintained, make reports as to their condition, the physical condition of the patrolmen, also their mental condition and the condition of the patrolmen's tools, etc. Copy of these reports are sent to the resident engineers, with the inspecting engineer's opinion as to the competency of the patrolmen, what they are doing, how they are doing it, etc. These reports are summarized and the summary is sent to the chief engineer. If there are any special points that the inspecting engineer wishes to call to the chief engineer's attention he marks the sheet with a red star, which indicates that there is an unusual condition existing to which he desires the chief engineer's attention called, and wishes him to go carefully into the details of his report. The chief engineer then refers the matter in question to the resident engineer with the necessary instructions to put the work in the proper condition, or asks for a report from the resident engineer concerning a remedy for the bad condition. In this way it is possible for the chief engineer to keep in close touch with each section of road, and is familiar with the efficiency of each patrolman.

The gang system has been used on a number of heavy traveled roads, and comprises a foreman, 7 to 10 men, taking care of from 40 to 60 miles of road. The gang is supplied with the necessary small tools, a roller, and a camping outfit. We found that while the gang system was slightly more economical the most satisfactory results were not secured owing to the fact that the intervals between which the gang passes over the road are so long that when there is a disintegration in the surface it cannot be fixed immediately, and the consequence is that by the time the gang visits the spot it is a large hole. Then, too, the men working in a gang are less efficient when separated than the patrolman, for they are in the habit of relying upon the instructions of the foreman of the gang and are not in the habit of thinking and acting for themselves.

The combination gang and patrol system is most satisfactory on sections of road where there are many cuts and fills and where the banks very often slide. In such cases it is the gang's duty to go over the roads early in the spring, remove all slides, shape all shoulders, open all ditches and culverts, make all the necessary repairs, and put the road in first-class condition. When this is done the roads are then turned over to the patrolmen, and they can take care of a larger number of miles than they could if required to do all the work in the spring by themselves. The combination patrol and gang system is more economical on certain types of road than the gang or patrol systems alone. It is, however, impossible to set any hard and fast rule as to whether the gang should be used on any section of road or the patrolmen. In any event, it is necessary before deciding upon any method of maintenance to study carefully the topography of the country, the character of the soil, the amount and kind of traffic, and the type of surfacing.

The writer believes that with a well organized system of maintenance and with carefully selected patrolmen, it is possible to maintain roads in the highest state of efficiency, and that at the end of a period of 10 or 15 years the roads will be in better condition than they were when first taken over from the contractor. To secure such results, however, it is necessary to build up the road and increase its thickness in accordance with the amount that is worn away by traffic. To know exactly how much the roads wear away each year a number of cross-sections are taken in the following manner:

Two permanent benches are established on each side of the road at the same elevation and a string is then stretched across which makes it possible to get an accurate measurement of the road surfacing. These readings are taken every 2 ft. apart transversely. This is done every six months and after each oiling, and a record is kept of exactly how much is worn off the surface of the road. Having this knowledge at hand, it is our object to place back on the road each year an amount greater than that worn off, and to accomplish this end we have increased the size of the screenings placed each year, during oiling, from ½ in. to 1½ in. The quantity of oil has been reduced from ¾ gal. to ⅓ and ¼ gal., and the quantity of stone chips has been gradually increased from 20 tons per mile to 125 tons per mile, depending upon the amount and intensity of traffic.

DESIGN AND CONSTRUCTION OF THE FOUNDATIONS FOR THE LINCOLN MEMORIAL, WASHINGTON, D. C.*

The Lincoln Memorial, which is under construction in Washington, D. C., at a cost of $2,000,000, is situated at one end of what might be called the main axis or base line of the grand development running west from the Capitol; this is fixed by the Capitol, the Washington Monument, and the Lincoln Memorial. The site is about 5,000 ft. west of the Washington Monument, and is on a line with 23d St.

Design Features.

Superstructure.—The structure is 204 ft. long by 134 ft. wide. It consists of a memorial hall, 84 ft. wide by 156 ft. long, surrounded by a colonnade of 36 massive columns representing the 36 states at the time of Lincoln's death. The height of the building itself is about 83 ft., and the memorial hall is divided into three sections by two rows of interior columns 50 ft. high. The base of the structure is 45 ft. above the original grade level, and it will be reached by means of terraces. The building is constructed of white marble. The interior lighting, in addition to that through the entrance, will be through thin marble slabs in the ceiling. Air passages are provided in the walls to reduce the condensation in the interior. The total weight of the structure above the original grade level is about 50,000 tons.

Foundation and Subsoil Conditions.—The foundation is divided into two parts: the upper foundation, including the part above the original grade level (elevation + 16), and the sub-foundation, extending from the original grade down to rock.

The upper foundation consists of 106 rectangular concrete piers, which vary in size from 3x6 ft. to 7 ft. 4 in. by 11 ft., all 45 ft. high. The 3x6-ft. piers are reinforced, and the 46 piers which support the superstructure columns are hollow, with walls 2 ft. thick. Connecting the exterior piers are reinforced concrete walls 1 ft. thick. The piers support the beams, arches, and the main floor. The concrete is a 1:2:4 gravel mix, with the exception of that in the solid non-reinforced piers, which is a 1:3:6 mix.

During the construction of the sub-foundation several mechanical analyses of the sand and gravel were made. The specifications required the sand to pass through a ¼-in. screen and the gravel to be retained by a ¼-in. screen and to pass through a 1½-in. screen. These curves were combined according to the rules of Fuller and Thompson.

The ideal curve for the 1½-in. gravel and the combined curves did not correspond. However, the proportion of the gravel larger than 0.8 in. in diameter was very small, and the ideal curve for the 0.8-in. gravel corresponds very closely with the combined curves, and shows the 1:2:4 mix to be the best obtainable. A small surplus of fine material was shown for the 1:2:4 mix. These results were corroborated by samples of concrete containing the two mixtures. The 1:2:4 concrete, when broken, showed a dense, compact mass, while the 1:3:6 mix showed small voids and required considerable manipulation to eliminate occasional honeycombing.

The sub-foundation consists of reinforced concrete piers supporting the upper foundation piers and extending down to and 2 ft. into bedrock, the mean elevation of which is – 34. The details of the sub-foundation will be given after a brief discussion of the subsoil and of the conditions governing the foundation design.

The subsoil strata and the proposed fill are indicated in the cross section of Fig. 1. The upper 16 ft. consist of a loamy sand, which showed no settlement under a test load of 4 tons per square foot. Below this stratum, and extending down to rock, is what was generally considered to be mud. However, except for the top 2 ft., which had been turned to mud by the ordinary vegetable growth in a tidal flat, the material is a kind of blue clay, which showed no settlement under a load of 1 ton per square foot. The bedrock, which is gneis, lies at an average depth of 49 ft. below the original ground level, and is covered with a 2-ft. layer of disintegrated rock.

---

*Based on article by Capt. James A. O'Connor, Corps of Engineers, in Professional Memoirs.

The results of 20 wet test borings showed that the clay was comparatively soft, and was of doubtful value as a foundation material. As rock was within reach there was no doubt that a practical solution of the foundation problem required that the structure be founded on rock. It was also decided that, since the foundation piers would be from 42 to 53 ft. long, they should be considered as columns, with sufficient cross section, or with sufficient reinforcement, to resist horizontal pressure. Details of the sub-foundation plan finally adopted are as follows:

The sub-foundation consists of 122 reinforced concrete circular piers, which extend 2 ft. into bedrock, and which are tied together with a cross bracing at their tops, at the original ground level. The diameter of these piers varies from 3 ft. 6 in. to 4 ft. 2 in., and each pier is reinforced with twelve 1¼-in. square twisted rods, with the exception of the 3-ft. 6-in. piers, which contain twelve 1-in. rods as reinforcement. The forms for these piers are steel cylinders, ½ in. thick for the lower 20 ft. and ⅜ in. thick for the remaining height. The cylinders were sunk to rock, the earth and rock excavated, the reinforcing steel placed, and the cylinder then filled with concrete. The cross bracing at the original ground level is concrete, 1 ft. thick, reinforced with ¾-in. square twisted rods, spaced 12 in. on centers, top and bottom. This cross bracing at the top of the sub-foundation piers, together with the 2-ft. penetration into rock, make a unit of the sub-foundation. Figure 2 (a) is a half sub-foundation plan showing the piers and cross bracing at the original grade, elevation + 16.0; and Fig. 2 (b) is a half upper foundation plan showing the piers, retaining walls, floor and wall arches, and the bracket slab.

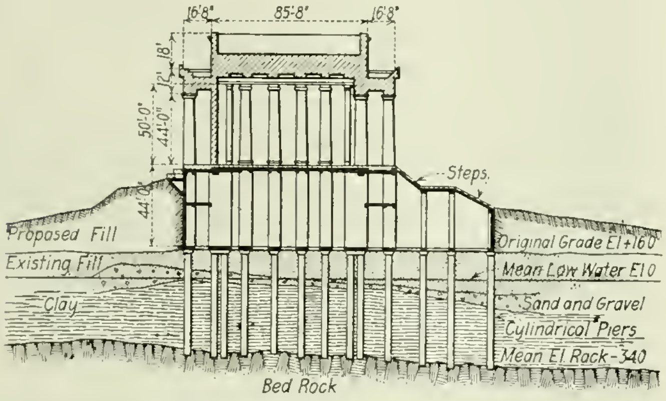


Fig 1

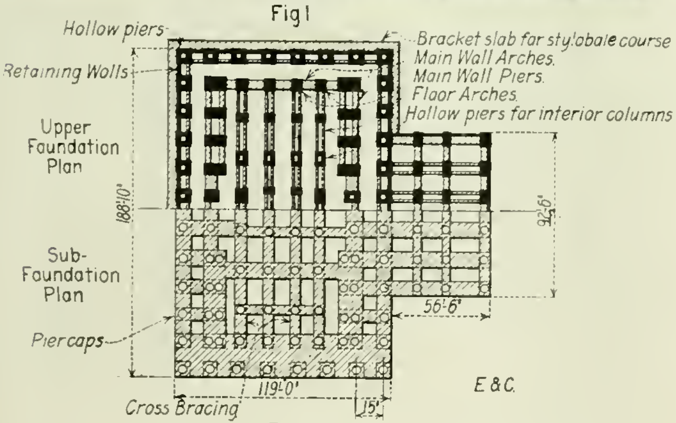


Fig 2

Fig. 1—Cross-Section of Lincoln Memorial, Washington, D. C., Showing Type of Foundation and Subsoil Conditions. Fig. 2—Half Plans of Sub and Upper Foundations of Lincoln Memorial.

An elaborate investigation of the foundation as constructed showed that the maximum concrete stress is 575 lb. per square inch, and the average unit stress less than 500 lb.; this investigation also showed that the foundation as a whole was stable against horizontal thrust, and that each pier was of sufficient strength to resist both the direct load and the lateral thrust.

Construction of Sub-Foundation.

From results of the borings it was expected that it would be necessary to use air pressure in working below water level. The wet clay, however, was decidedly watertight, and the only trouble was from water which came through the porous top sand layer.

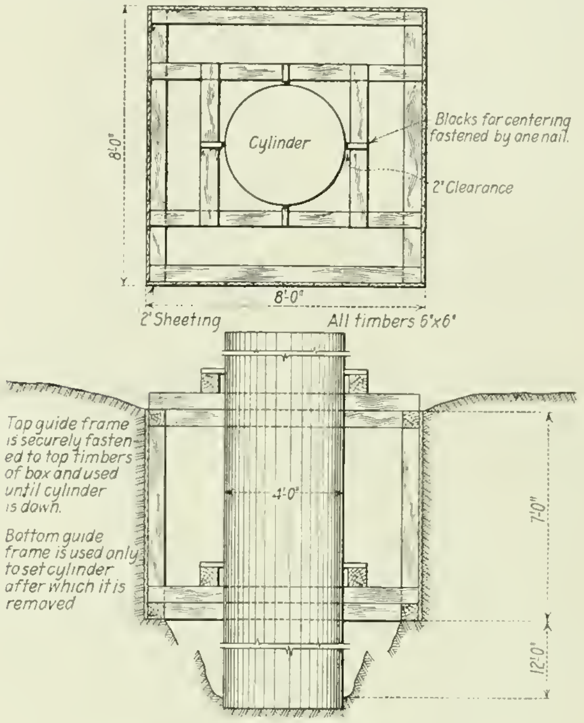

Cylinder
Blocks for centering fastened by one nail.
2" Clearance
8'-0"
8'-0"
2" Sheeting
All timbers 6"x6"
Top guide frame is securely fastened to top timbers of box and used until cylinder is down.
Bottom guide frame is used only to set cylinder after which it is removed
4'-0"
7'-0"
12'-0"

Fig 3

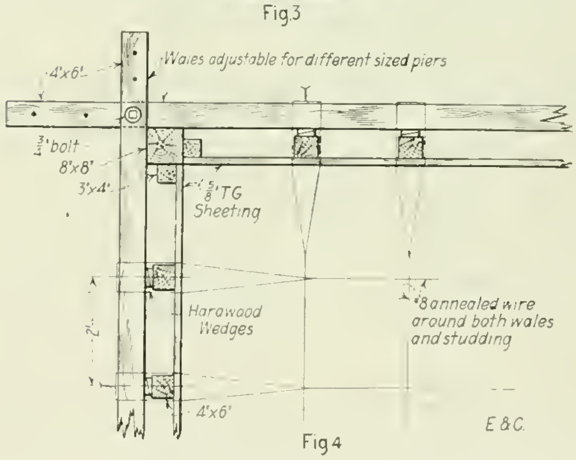

Wales adjustable for different sized piers
4"x6"
¾" bolt
8"x8"
3"x4"
⅞" TG Sheeting
Hardwood Wedges
8 annealed wire around both wales and studding
2'
4"x6"
E & C

Fig 4

Fig. 3—Plan and Sectional Elevation of Crib Used in Sinking Cylinders for Foundation of Lincoln Memorial. Fig. 4—Corner Section of Forms for Upper Foundation Piers of Lincoln Memorial.

The equipment included a complete air-compressor plant with two 60-hp. locomotive-type boilers, an air compressor and an air lock. For setting the cylinders and handling the material there were two 10-ton stiff-leg skid derricks.

The original plan was to excavate from inside the cylinder with a 2-cu. ft. orange-peel bucket. However, the material was too stiff to make this plan successful, and the excavation had to be made with short handled shovels. The material was lifted out in large buckets by two small cranes, which were later added to the equipment. The general plan was first to make the initial excavation, then to set the cylinders and sink them with large derricks, and finally to follow up with the small derricks for excavating from the interior of the cylinders. The actual sinking of the first cylinder began Feb. 27, 1914.

Sinking of Cylinders.—In sinking a cylinder an 8x8-ft. box or crib was first sunk through the sand until the lower edge was resting in the clay (see Fig. 3). The crib was placed in position and sunk with an orange-peel bucket. Next, a hole about 12 ft. deep was dug into the clay. Guides were placed on the top and bottom timbers of the crib, and the first section of the cylinder, 27 ft. long, was placed. The weight of this cylinder section was sufficient to sink it into the clay and to fix it firmly in position. The cylinder was then loaded, usually with five 2½-ton concrete blocks, which sank it until its top was level with the top of the box. The interior was then excavated by hand to a depth of 2 or 3 ft. below the cutting edge, when the second section, 13 ft. long, was placed in position and bolted. To sink this section required 20 tons of weight and jetting around the outside of the cylinder with a 2-in. jet. The inside was again excavated below the cutting edge, and the third section added to the cylinder. This settlement generally required a load of about 30 tons, and in some cases it was necessary to jet around the outside for the full length of the cylinder. After the removal of the 2-ft. layer of disintegrated rock the final settlement of the cylinder to solid rock again required a load of about 30 tons, and considerable jetting.

The jetting was the principal cause of trouble with water. It opened up a passage for water to seep down from the top along the exterior surface of the cylinder, and considerable quantities had to be removed before the final placing of the concrete. The next step was the excavation of the rock to a depth of 2 ft., which was done by blasting. The reinforcement was then placed in position.

Placing Reinforcement and Concrete.—The reinforcement for a cylinder was assembled on the ground; it consisted of twelve 1¼-in. or 1-in. bars, averaging 52 ft. long, spaced and tied to a 7/16-in. spiral hoop reinforcing. To prevent the collapse of the unit the rods were bolted to three 1x6-in. steel rings, one at each end and one in the center. These rings were left on the assembled units until after the reinforcement was set in place by the derrick and wedged in the cylinders.

The concrete was placed in the cylinders with a bottom-dump bucket of ½ cu. yd. capacity, which was lowered by a small derrick and tripped after the previous batch had been tamped with the loaded bucket.

The water was removed by bailing, with buckets holding about 12 cu. ft. This method was found to be more rapid and economical than the steam siphon, which was used only to handle the water at moderate depths. The water caused a great deal of trouble, and it is probable that it could have been handled more readily by a portable pump.

Method of Withdrawing a Cylinder.—Several piles were encountered in sinking the cylinders. Fortunately most of them came inside the cylinders, and were dug out. One pile, however, caused a cylinder to sink 3½ ft. out of line, and this cylinder had to be redrawn and sunk again. This was the only use made of the air plant, the rock drilling being done by a small air compressor attached to a derrick.

In withdrawing the cylinder an air-tight bulkhead of 6-in. timbers was fastened to the top of the cylinder by means of angles, and the cylinder was allowed to fill with water. An upward pull of over 50 tons was exerted on the cylinder by means of jacks and chains. The air valve was then quickly opened, with the compression in the air tank at 100 lb. per square inch. The object in filling the cylinder with water was to limit the air space, since it takes an appreciable length of time to overcome the inertia of a 50-ft. column of water. Careful observations on the pressure gage showed a pressure of 90 lb. per square inch for several moments after the air valve had been opened. The first twelve attempts raised the cylinder 1 in., the jacks being adjudged each time. On the thirteenth attempt the cylinder shot upward 15 ft. and was then easily removed.

Cost Data.—The costs in the sub-foundation work varied considerably, due to the varying weather and other conditions. The average cost of sinking and excavating the material within a cylinder, ready for the reinforcement was as follows:

Overhead	$ 37.50
Plant equipment	99.50
Supervision and labor	207.50
Average cost of cylinder	188.00
Total	$532.50

The cost of assembling and placing the steel reinforcement averaged $13.45 per cylinder.

The total cost of the concrete in place, excepting the concrete materials, but including overhead, plant and equipment, supervision, and labor, was $1.78 per cubic yard. The concrete materials cost $3.35 per cubic yard of concrete. Common labor was paid 20 ct. per hour.

Construction of Upper Foundation.

The construction of the upper foundation was similar to massive concrete work of the same character. The only unusual feature was the requirement that certain piers were to be poured to a height of 37 ft. in one operation.

A corner of one of the forms is shown in Fig. 4. The waling pieces were spaced 2 ft. 6 in. on centers vertically, and the corner posts were made up in one 12-ft., two 10-ft., and one 5-ft. section, for convenience in handling and adjusting to the various heights. When the forms were removed the top 5-ft. section was left in place to carry the beam, arch and floor forms. Some of the 3-ft. 6-in. piers were poured in 1½ hr.

The effect of curing and temperature variations were clearly shown in the main floor slab. This slab, which was 7 in. thick and was reinforced with 0.30 sq. in. of steel fabric per foot of width, was poured in three sections, each approximately 60x120 ft. After several rainy days water would seep through the minute cracks, which are otherwise invisible, and thus show their location on the bottom of the slab. The beams and arches between the piers supporting the slab, in general, run in a north-and-south direction, and, being protected, are not subject to the same temperature variations as the overlying slab, as is shown by the general east-and-west direction of the cracks. Except in places where the beams and arches prevent an east-and-west movement of the tops of the piers there are no north-and-south cracks in the slab.

Some average costs of the upper foundation work are herewith given:

The total cost of building and stripping the forms for the piers and retaining walls was 11 ct. per square foot, and that for the beams, arches and floors, 22 ct. per square foot. The cost of the concrete per cubic yard in place, excepting the materials, was:

Item.	Piers and retaining walls.	Floor-beams and arches.
Overhead	$0.10	$0.19
Plant and equipment	0.32	0.37
Supervision and labor	0.63	1.09
Total	$1.05	$1.65

The foundation was completed and accepted in March, 1915.

DATA ON CENTRAL STATION HEATING IN THIRTEEN MINNESOTA CITIES.

The data given herewith on central station heating in Minnesota cities were compiled by John V. Mertenis, Professor of Heating and Ventilation, University of Minnesota, for the Municipal Reference Bureau of the League of Minnesota Municipalities. The data were published in Minnesota Municipalities, the official organ of the League, for February.

Of the 13 plants listed in Table I, seven are municipally and six are privately owned. The source of heat is primarly the exhaust from the power units in the plant, although live steam is used to make up any deficiency of the exhaust steam supply. This condition will occur in any plant where the heating load is based on the average power load. The amount of radiation per boiler horsepower varies from 30 to 90 sq. ft.; the latter amount appears to correspond more nearly to average operating conditions.

The heating system used in most cases is direct steam,

TABLE 1.—DATA ON CENTRAL STATION HEATING IN 13 MINNESOTA CITIES.

City.	Population.	Ownership.	Heat Source.	Boiler H.P.	Heating System	Amount Radiation.	Distance Carried.	Pressure in Mains.	Pressure Service.	Charges.
Alexandria	3,001	Municipal	Live Steam	300	Direct		6 Blocks			
Crookston	7,559	Private	Exhaust and Live Steam	625	Steam Direct	not given	½ mile	5 lbs.	5 lbs.	60c per 1,000 lbs.
Detroit	2,807	Municipal	Exhaust and Live Steam	3-66x16 300	Steam Direct	26,000 sq. ft.	not given	5-6 lbs.	not given	40c per 1,000 lbs.
Glenwood	2,161	Private	Exhaust and Live Steam	1-78x20 1-72x18 350	Steam Direct	not given	700′	4-5 lbs.	4 oz.	45-85c per 1,000 lbs.
Hibbing		Municipal	Exhaust Steam		Direct and Indirect	1,600 Direct 1,300 Indirect	700′ to 1,200′	3½ lbs.	3½ lbs.	42c sq. ft. Rad. or 60c per 1,000 lbs.
Jordan	151	Private	Exhaust and Live Steam	2-54x14 1-72x18 270	Direct Atmospheric	14,000 sq. ft.	3 Blocks	3-8 lbs.	6-9 oz.	60c per 1,000 lbs.
Litchfield	2,333	Municipal	Exhaust and Live Steam	72x18 300	Steam Steam	27,000 sq. ft.	700′ 1,200′ to end	3-5 lbs.	3	40-60c per 1,000 lbs. $4.00 mo. min.
Long Prairie	1,250	Municipal	Exhaust Live on Sunday	1-54x14 1-72x16 185	Steam Direct		360′	1½ lbs.	1½	35c per 1,000 lbs.
Mapleton	809	Private	Live Steam	120			250′			
St. Paul	214,744	Private	Exhaust Economizer	6,000	Direct Indirect Vacuum	700,000 Direct 10,000 Indirect	Varies	3-8 lbs.	3	54-81c per 1,000 lbs
St. Paul	214,744	Private	Live Steam		Direct Indirect Steam	100,000	2,000′	140 lbs.	6 lbs.	54c per 1,000 lbs.
Staples	2,558	Municipal	Exhaust and Live Steam	275	Direct Steam		1,800′	3-5 lbs.	3	40c per 1,000 lbs.
Virginia	10,473	Steam Purchased	Exhaust Steam	600	Direct Steam	17,910	1 Block	3 lbs.	3 lbs.	25c per sq. ft. Rad.

which is cheaper to install than hot water, although the latter has been satisfactorily installed in other states.

With the exception of one plant the pressure carried on the main is low and the service pressure does not exceed 5 lb. gage.

The charges for services vary from 35 to 85 ct. per 1,000 lb. of condensation. The rate decreases uniformly as the amount of heat used increases.

The private plant rates are somewhat higher than those of municipal plants, but are not excessive in any case.

A STUDY OF CRACKS IN A CONCRETE ROADWAY AT INDIANA UNIVERSITY.

By Ulysses S. Hanna, Professor of Mathematics, Indiana University.

The old main entrance roadway into the grounds of Indiana University was 12 ft. wide and 15 in. in depth of waterbound macadam and had cobblestone gutters 2 ft. in width. The increased traffic using this drive made it necessary to widen it and the Board ordered it paved with Portland cement concrete 25 ft. wide. This width includes the 6-in. curbs which were made a part of the pavement itself.

The old stone gutters were removed and the proper excavation made on each side to get the required width and depth. The old macadam was then thoroughly loosened by plowing to its full depth and scattered over the newly excavated parts so that after rolling it was of uniform depth throughout of approximately 6 in., except at the immediate entrance to the campus where for a distance of 200 ft. the grade was lowered so that all of the macadam was removed.

The grade of the new drive was set to fit the macadam, as far as possible, by placing 10-in. boards to line and grade of the back of each curb. This was done after the drive was rolled with a ten-ton roller. After setting the boards the small inaccuracies of the subgrade were corrected and the whole drive was again thoroughly rolled. The location of the drive is such that the drainage is away from the pavement on each side. For this reason no subdrainage was provided. The present condition of the pavement, however, may indicate that this was a mistake.

The first layer of concrete was placed so that it was 4 in. thick after being well tamped. The mixture was 1:3:5 of Universal Portland cement, clean sharp river sand from Gosport and crushed Mitchell limestone that was passed over a revolving screen with ⅛-in holes placed as close together as possible and then through a revolving screen of holes 2 in. in diameter. The mixing was done in a good mechanical batch mixer and at all times the concrete as it was placed gave every appearance of being of an excellent quality. The mixing was under careful inspection the entire time and the quantities were correct to specification.

On this first layer, before tamping, was placed "Econo" expanded metal reinforcement of diamond mesh, about 3 in. wide by 6 in. long, and of weight and cross-section to meet the standard tests. The metal was in sheets 4 ft. wide by 12 ft. long and was placed to lap never less than 4 in., but usually 6 to 10 in. The long axis of the diamond was placed longitudinally with the drive. Seven sheets were used to make the 25-ft. width, the laps being such that the outer edges of the reinforcement usaully came about in line with the face of the curbs.

After thorough tamping, which for the most part forced the reinforcement into the first layer, the wearing surface, 2 in. thickness of a 1 to 2 mixture of cement and sand, was placed and floated with wooden floats. The curbs were made of the finishing mortar by clamping 4-in. facing boards to the back boards, blocked so that the curbs were 6 in. wide. The extra expense of making the curbs entirely of the finishing mortar was offset by the saving of time and labor over what it required to give the curb a concrete core. The curbs were not reinforced in addition to the expanded metal as it extended into them from the pavement. This lack of reinforcement has permitted occasional fine cracks from the top of the curb down to the pavement and sometimes running a few inches into the pavement. Half-inch joints were made in the curbs over all expansion joints in the pavement.

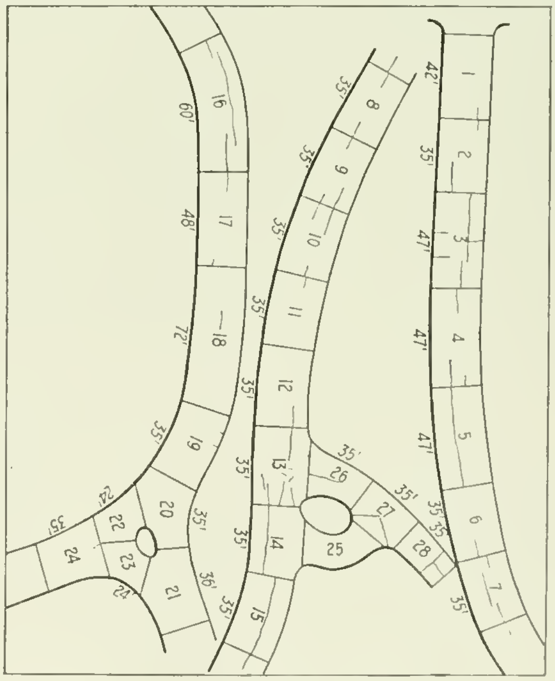


Diagram of Cracks in Concrete Roadway at Indiana University.

---

*Paper read at the annual meeting of the Indiana Engineering Society.

Expansion joints as a rule were placed every 36 ft. There are 19 blocks of this length, two 24 ft. long, four 48 ft. long, 1 60 ft. and one 72 ft. These extra lengths were made for reasons obvious to one on the ground at the time and also for the purpose of observation. The joints were made by staking short 2x6-in. boards and placing against these boards "Elastite," a tarred paper preparation about 3/16-in. thick, and dropping the finishing mortar the full depth of 6 in. extending back from the joint 2 to 3 in. By the time the succeeding block was ready for the top mortar the boards could be removed without injury to the joint and the top mortar allowed to go the full depth as before. The pavement has been in place eighteen months and no joint has yet been found to show any chipping or disintegration. It is believed that a carefully made joint of this character will give less trouble than one in which iron plates are anchored into the blocks of concrete.

In finishing the surface with the wooden floats no pains were taken to get it smooth other than to cut off and fill up the inaccuracies of the spreaders. In fact the surface was left as rough as a soft pine wood float could make it. The maximum gradient on the drive is 6⅔ per cent, and the center is crowned between 2½ and 3 in. A considerable amount of heavy hauling has been observed and no difficulty of securing easy footing has ever been noticed.

The subgrade was always made reasonably wet just before the concrete was placed. It was the intention to cover the finished work with the clay excavated on the sides of the old drive and it was left on the sides of the new drive for this purpose. The weather, however, was cool and the atmosphere quite moist, owing to frequent summer showers, during the time of the work, and most of the drive was in the shade of the campus trees. For these reasons the covering was dispensed with and one of the campus attendants spent most of his time sprinkling the finished pavement from the campus hydrants for a space of ten days following the laying.

I speak of these details that it may be known that care was exercised in following the usual instructions for securing a good piece of work. This is the only piece of concrete pavement in this locality and it was the constant endeavor of both the contractors and the University authorities to secure good results. We had a representative of the Cement Manufacturers' Association with us three days at the beginning of the work and were glad to have the suggestions offered by him, he being an engineer of experience. Were it not for the cracks that have appeared we would feel extremely well satisfied with the results.

The two 24-ft. blocks have no cracks in them of any kind so far as close examinations from time to time can reveal. Of the 19 36-ft. blocks only two are entirely free from cracks. In most of these nineteen blocks, however, there has appeared thus far but a single crack at either end and in most instances extending the length of a single piece of the reinforcement or less. Also in all these nineteen blocks there is but one crack extending crosswise of the pavement, it being 12 ft. from the end of one branch of the drive. All the other lateral cracks, three in number, occur in one 48-ft. block located near the entrance, where all of the old macadam was removed. This block also has two longitudinal cracks, making it the worst block in the whole pavement. Rarely does a longitudinal crack occur closer to the curb than the second lap of the reinforcement and when it does there is usually a parallel crack closer to the opposite curb. In only three blocks in the whole pavement does any crack extend the full length of the block. In four additional blocks cracks extend the whole length of the blocks by jumping the width of one or more laps of the reinforcement. As an example I may cite the first crack that was discovered in the whole pavement. It appeared in the 60-ft. block the first winter. It started on the second lap of reinforcement from the north curb near the center of the block and slowly worked toward the ends of the block going to a point 12 ft. from the east end and to a point 8 ft. from the west end. At each end there is a parallel crack one lap farther south and extending in from the ends the length of one piece of reinforcement.

In the 72-ft. block there has appeared but a single crack and it was found just recently. It is longitudinal and is near the center line at the middle of the block. At present it is about 8 ft. long and is very hard to see. I have watched this block and the 60-ft. block rather expectantly for lateral cracks but none can be found.

There are eleven cases where a crack in one block is matched by a corresponding crack in the adjoining block and there are seventeen cases of cracks at the ends of the blocks without corresponding cracks in the adjacent blocks. There are four cracks that run diagonally with respect to the lapping of the reinforcement, all of which are less than 12 ft. in length. Two of these are in one block and they unite to form a "V" opening toward the entrance to a branch drive. Two of the lateral cracks in the 48-ft. block mentioned above are near the middle of the sheets of reinforcement. Many of the longitudinal cracks vary 2 and 3 ft. from a straight line parallel to the curbs, thus showing that the cracking is not altogether due to insufficient lapping of the reinforcement. The distance of the crack from the curb often puts it in the center of a strip of reinforcement.

There are several elements that may have entered into the cause of these cracks. It would be interesting and instructive to know, if it were possible, just what part each element had to do with it. Some are almost certainly due to insufficient lapping of reinforcement. Others appear to be due to failure to secure a subgrade of uniform density. Lack of proper drainage may also have had a part in it.

STATEMENT OF THE OWNERSHIP, MANAGEMENT, CIRCULATION, ETC., REQUIRED BY THE ACT OF CONGRESS OF AUGUST 24, 1912,

of Engineering and Contracting, published every Wednesday at Chicago, for April 1, 1916.

State of Illinois, County of Cook, ss.—Before me, a notary public in and for the state and county aforesaid, personally appeared H. P. Gillette, who, having been duly sworn according to law, deposes and says that he is the Editor of Engineering and Contracting and that the following is, to the best of his knowledge and belief, a true statement of the ownership, management (and if a daily paper, the circulation), etc., of the aforesaid publication for the date shown in the above caption, required by the Act of August 24, 1912, embodied in section 443, Postal Laws and Regulations, printed on the reverse of this form, to-wit:

1. That the names and addresses of the publisher, editor, managing editor, and business manager, are:

Publisher—The Myron C. Clark Publishing Co., Chicago, Ill.
Editor—Mr. H. P. Gillette, Chicago, Ill.
Managing Editor—Mr. C. S. Hill, Chicago, Ill.
Business Manager—Mr. H. P. Gillette, Chicago, Ill.

2. That the owners are: (Give names and addresses of individual owners, or, if a corporation, give its name and the names and addresses of stockholders owning or holding 1 per cent or more of the total amount of stock):

The Myron C. Clark Publishing Co., Chicago, Ill.
H. P. Gillette, Chicago, Ill.
N. M. Clark, Chicago, Ill.

3. That the known bondholders, mortgagees and other security holders owning or holding 1 per cent or more of total amount of bonds, mortgages or other securities are: (If there are none, so state.) —None.

4. That the two paragraphs next above, giving the names of the owners, stockholders and security holders, if any, contain not only the list of stockholders and security holders as they appear upon the books of the company, but also, in cases where the stockholders or security holder appears upon the books of the company as trustee or in any other fiduciary relation, the name of the person or corporation for whom such trustee is acting, is given; also that the said two paragraphs contain statements embracing affiant's full knowledge and belief as to the circumstances and conditions under which stockholders and security holders who do not appear upon the books of the company as trustees, hold stock and securities in a capacity other than that of a bona fide owner; and this affiant has no reason to believe that any other person, association, or corporation has any interest, direct or indirect, in the said stock, bonds or other securities than as so stated by him.

5. That the average number of copies of each issue of this publication sold or distributed through the mails or otherwise to paid subscribers during the six months preceding the date shown above is— (This information is required from daily publications only).

H. P. GILLETTE,
Business Manager.

Sworn to and subscribed before me this 30th day of March, 1916
(Seal.) C. E. MEINDERS.
(My commission expires June 7, 1916.)

Note.—This statement must be made in duplicate and both copies delivered by the publisher to the postmaster, who shall send one copy to the Third Assistant Postmaster General (Division of Classification), Washington, D. C., and retain the other in the files of the post office. The publisher must publish a copy of this statement in the second issue printed after its filing.

Engineering and Contracting

Devoted to the Economics of Civil Engineering Design
and to Methods and Cost of Construction

EDITORS
H. P. GILLETTE C. S. HILL C. T. MURRAY S. C. HADDEN C. W. MALCOLM

Volume XVI. CHICAGO, ILL., APRIL 19, 1916. Number 16.

THE THREE CHARACTERISTICS OF GOOD TECHNICAL ARTICLES.

"Excuse the great length of this letter," wrote a celebrity to a friend, "for I did not have the time to write a short one." Brevity is not only the soul of wit but the badge of strenuous effort. To express the essential features of an engineering achievement in a few words usually implies a long time devoted to eliminating nonessentials. It is easy to be garrulous, but difficult to be concise.

Engineers are perhaps less verbose than other classes of men in describing their work. However, a noticeable fault of writers on engineering subjects is the presentation of non-usable facts. The iterated and reiterated criterion for technical writers is: Will the sentence that I have just written add measurably to the usable knowledge of men engaged in this sort of work?

Conciseness and utility—of these we have spoken. The third characteristic of good technical articles is novelty. It is no exaggeration, we believe, to say that half the papers and articles on road construction and design contain next to nothing that is novel, and that of the other half the novel parts constitute a very small percentage of the total. Why does nearly every writer on roads, for example, waste sentences and even paragraphs about "the paramount importance of good drainage"? Must we have "the principles of drainage" dinned into our ears forever? Julius Cæsar probably began it in his lectures on the Appian Way. Who, in the name of novelty, will cease it? It is a pretty good rule not to repeat in an engineering article what is already to be found in engineering books.

NEWSPAPER PUBLICITY OF ENGINEERING MATTERS.

If any engineer still believes that it is impossible to obtain desirable publicity of engineering matters in the daily press we wish to refer such a man to the front page of the April 13, 1916, issue of The Chicago Daily News. Without any search he will here find a column article on engineering matters considered in connection with the second conference of the Committee on Engineering Co-operation, held in Chicago last week.

We assert that publicity of this kind will do more to place the engineering profession in a proper light before the general public than other procedure. The man responsible for the article referred to is C. E. Drayer, of Cleveland, Ohio, secretary of the above committee, who has done more than any man known to us in securing desirable newspaper publicity of engineering matters. He has demonstrated many times that the daily press will print engineering articles if such articles are properly written and possess news value. The Daily News is widely recognized as a conservative and reliable newspaper, and its circulation is greater than that of any other newspaper in Chicago. That such a newspaper recognizes the value to its readers of information on engineering subjects is to its credit. Engineers may well study the article referred to, and others published recently in the daily press, and emulate the example set by those responsible for such articles.

SUBGRADE PREPARATION; AN EXAMPLE OF INDEFINITE TERMINOLOGY.

There are few terms used in concrete road construction which are less definitive than the term subgrade preparation. To lay concrete pavement the surface of the roadbed must be uniformly firm and true to horizontal and longitudinal profile. Arrival at this requisite is the result of several construction processes. The full schedule includes: Clearing, grubbing, excavating, filling, drain construction, shaping and rolling. It is rare that the full schedule of process is required in constructing any one road, but in constructing most roads all but the first two processes are required. Which of these processes or what picture of any or all of them are comprehended by the term subgrade preparation? As stated above, current practice in the use of this term does not provide a definite answer. In seeking something definitive, let us analyze practice as it is recorded in recent writings on concrete roads.

Without exception clearing and grubbing are excluded processes. However, except in original road location clearing and grubbing are seldom required construction processes and in the sections of the country where concrete roads are very liable to be much adopted original road location is unusual. We may, therefore, regard clearing and grubbing as processes outside of our immediate concern. Consider next excavation and embankment: When cuts and fills are of a depth of, say, 12 to 18 in. practice is quite general, but not universal, in excluding them as processes of subgrade preparation. Excavation and embankment of less depth than, say, 12 in., including plowing, harrowing and scraper or road grader work, are commonly included in subgrade preparation processes. Drainage ditches and subdrains, like cuts and fills, are excluded or included largely according to their individual magnitude as a construction task. Shaping the grade and compacting the surface soil are commonly classed as subgrade construction processes.

The preceding is, we imagine, an analysis of practice which will be accepted by those familiar with practice, as substantially correct. It indicates without chance for dispute too wide limits of inclusion of earthwork processes to permit a definite conception of the tasks involved when the term subgrade preparation is used without full explanation. One boundary is marked by the finishing processes of shaping and rolling to final profile; the other boundary is marked by the broad operation which includes all the processes of plowing, harrowing, grading, shaping, drain construction, finishing and compacting the top foot or two of roadbed. No trustworthy cost comparisons are possible of subgrade preparation when such a wide range of processes is included within the meaning of the term. Correction of such a condition is demanded.

SCIENTIFIC MANAGEMENT AND LEGISLATION.

In an attempt to restrict, by legislation, the employment of the principles of scientific management in government works organized labor is again active at the present session of Congress. In opposition to such legislation a number of prominent manufacturers and other advocates of the Taylor and similar systems of scientific management attended the recent hearings conducted by the

House Committee on Labor on the Tavenner bill, which prohibits time study, the use of the stop watch, the payments of premiums and bonuses, and other adjuncts of scientific management. The principal opposition to the bill at these hearings came from representatives of the National Association of Manufacturers and the Chamber of Commerce of the United States, although anyone seeking to further the adoption of efficiency principles is interested in the defeat of the bill. As framed, the bill contains an exception to the prohibition of the payment of any premium, bonus, or cash reward in that it permits payment for any "suggestion resulting in economy or improvement in the operation of any government plant." It is thus seen that the government, or any officer of it, may pay a cash reward for any suggestion made by an employee, but is prohibited from making such a payment for doing certain acts which contribute to improvement and economy in the operation of a plant.

Those organizations and individuals seeking to secure the passage of this bill are laboring under the misconception that legislation is desirable to prevent the introduction of devices and methods tending to make the individual more efficient and to increase his powers of production. We believe the laboring man will, in the end, gain most by facilitating the adoption of those principles of scientific management which tend to increase his production and conserve his energy. It is largely his own fault if an increased production on his part does not bring to him greater financial return. On the other hand, he cannot expect long to profit at the expense of production. An increased rate and shorter hours, provided that rate does not tax his strength unduly, should be more profitable to the workman than merely putting in long hours. If the present representatives of labor interests can exert enough influence to secure the passage of this bill their success will probably lead them to seek, by future legislation, the prohibition of the use of scientific management principles in private plants.

BIDDING ON CONCRETE BRIDGE WORK.

That bidders on concrete bridge work have no common method of estimating the cost and value to them of such work is evidenced by the bids received on March 15 for three reinforced concrete arch bridges over the Great Miami River at Dayton, Ohio. One of these bridges will consist of seven 80-ft. 11⅞-in. clear spans, another of three 90-ft. 8⅞-in. clear spans, and the third will have three clear spans of 110 ft. 9 in. each; all will have 40-ft. clear roadways and two 8-ft. 2-in. sidewalks. Exceptionally complete information of use to the contractor in making up his bid was given in the plans and specifications. This information included a map of the site and adjacent territory, showing street and railway facilities and space available to the contractor, together with very complete data on the subsoil and on flood and low-water conditions. On account of the completeness and accessibility of reliable information the resulting low and high bids on each of these bridges, which follow, are of interest:

For constructing the first mentioned bridge 18 bids were received, the low bid being $116,930 and the high bid $188,570. For the second bridge there were 21 bidders, the low bid being $61,014 and the high one $136,282. The third bridge brought out 24 bids, the lowest of which was $61,797 and the highest $112,837. The ratio of low to high bid for each of the three structures is: 1:1.6 for the first, 1:2.2 for the second and 1:1.8 for the third. It is of interest to note that all three bridges were awarded to the same company, the Pacific Bridge Co. of Portland, Ore. This company had the low combination bid of $239,026 for the three structures, taking into account the stipulations that $2,000 were to be deducted if the company was awarded the largest bridge and either of the smaller ones, and $5,000 if it was awarded all three bridges. It is of further interest to note that this combination bid is $715 below the sum of the low individual bids received for the three structures. In no case did the successful company submit the low bid on any one of the bridges, although none of its separate bids exceeded that of the low bidder by more than $2,100.

The above facts, and others, in connection with the letting of these bridges offer an interesting study of some of the problems of the bridge contractor of today. In this case a total of 63 bids was received for the three bridges, yet all bridges were awarded to one company. We wish it was within our power to state the conditions governing each contractor's bid, and why one contractor figured that his force and equipment were worth 2.2 times as much as another. We should also like to know how many bidders made careful estimates based on available facts and how many guessed important factors of their bids, and whether or not the successful (?) contractor will realize a fair profit.

THE IMPORTANCE OF PROPER SEWER MAINTENANCE.

Admitting that the ideal sewer is one which could safely be forgotten, the fact remains that the ideal has not yet been attained in sewer construction. Therefore, despite the natural impulse to build a sewer and then forget it, some thought must be given to proper sewer maintenance.

The latest annual report of Mr. William H. Connell, chief, Bureau of Highways, Philadelphia, calls attention to the fact that proper sewer inspection and maintenance are decidedly worth while from economic and service standpoints. A few facts gleaned from that report are of general interest. The number of complaints received, in the city, was reduced about 15 per cent following the systematic cleaning and inspection of sewers in the central section of the city and the making of minor repairs of routine nature. The advisability of periodical inspection and cleaning is best shown through the reduction in the number of complaints in the central district alone, where the decrease for one year amounted to 35 per cent. As a result of this work the year was singularly free from the extensive reconstruction work which generally follows heavy storms and freshets that test sewers to capacity and play havoc with the weak links of the system. During 1915 the first systematic cleaning of the sewers was undertaken and splendid results were obtained. The sewers were thoroughly inspected while being cleaned and minor repairs were made, so that no serious cave-ins of sewers occurred on the cleaned sewers during the year. Commenting on this fact, Mr. Connell says:

> This unquestionably demonstrates the value of what might be termed "preventive work in the maintenance of sewers." The cleaning in itself is not only necessary to insure their proper operation and thus prevent the backing up of sewage into cellars and the overflowing of streets, but it provides for a patrol system of inspection which catches up the many minor defects that natural deterioration brings about and ultimately prevents serious breaks.

Another reason for sewer inspection which is decidedly worth while is that it gives facts about the serviceability of the different classes of material used in constructing sewers. It is quite conceivable that the actual underground inspection of a sewer will reveal conditions differing widely from what one previously supposed those conditions to be.

ERRONEOUS DATA ON THE LIVES OF BUILDINGS.

If we exclude buildings of the flimsiest type—corrugated iron, etc.—few buildings that are properly maintained come to the end of their lives as the result of rot, corrosion or other natural causes. It may be stated as an almost universal rule that the lives of buildings reach an end solely because of obsolescence, inadequacy and fire. The alleged "average lives" of buildings published in books and articles are therefore not natural lives but functional lives. As no explanation accompanies tables of lives of buildings it is commonly, but erroneously assumed that the tables give natural lives.

A recent instance of this error is to be seen in an article by Mr. J. C. Bannister in Engineering Record, Apr. 8. In

TABLE I.—MEAN LIFE OF BUILDINGS—BRICK APARTMENT, CLASS "C."

Material.	l Life relative to 75 yr., per cent.	c Cost relative to total cost of building.	l × c Cost of Items.
Foundations	100	11	$1,100
Masonry	100	16	1,600
Steel	100	11	1,100
Lumber	50	20½	1,025
Ornamental iron	50	2½	125
Plaster	50	10	500
Partitions	50	2	100
Electric wiring	33	3	100
Painting	10	3	30
Plumbing	33	12	400
Heating	33	4	132
Marble and tile	25	5	125
		100	$6,337

$\frac{6337}{100}$ = 63.37 per cent of 75 yr., or a mean life of 47½ yr.

the appraisal of real estate in Los Angeles for tax purposes, the reproduction cost of buildings was estimated by applying unit prices to the number of cubic feet or square feet of floor area in each building. The natural depreciation was then calculated for each building by applying life tables to the known age of each building. Mr. Bannister says:

> It should be made clear that this depreciation includes nothing but the natural decay of material comprising the structure, and contains no element of obsolescence.

Table I shows the general method of estimating the composite life of each type of building and Table II gives the estimated natural life of various types of buildings. Mr. Bannister says:

> A study of these results showed that for all buildings other than those of frame construction the length of life given corresponds very closely with those used in doing similar work in other cities, and by such authorities as Bernard, Sommers and the Wisconsin Tax Commission.

True, but this "checking" makes the data as to lives none the less erroneous. A study—and the editor has made a very thorough study—of published life tables of this sort discloses a somewhat astonishing copying of what some other "authority" has written on depreciation. There are, in fact, practically no published data on the actual lives of specific buildings or their component parts. Each "authority" is therefore at liberty to guess to his heart's content, secure in the knowledge that his guess is likely to be as good as that of his predecessors. But all of these guesses as to the natural lives of buildings can be shown to be not even reliable as guesses.

Take Mr. Bannister's Table II and ask him or any other man to cite a single hotel, for example, that he knows to have been torn down at the end of 50 or 60 years because the forces of nature have rendered it uninhabitable. Hotels have become obsolete or inadequate it is true, and have been torn down within 50 years of their construction, but the editor has quizzed many a man and has searched all published records in vain for a single instance of a brick or masonry building that had been removed within 100 years of its erection because the forces of nature alone had rendered it worthless.

TABLE II.—NATURAL LIFE OF BUILDINGS.

		Life in years.
Cal. House	Good	25
	Medium	20
	Poor	15
Sheds	Good	25
	Medium	20
	Poor	15
Garage, Barns	Good	20
	Medium	17.5
	Poor	15
Bungalow	Good	35
	Medium	30
	Poor	25
School, Church, Stores	Good	35
	Medium	30
	Poor	25
Apartments, Flat	Good	30
	Medium	27.5
	Poor	25
Residence	Good	40
	Medium	35
	Poor	30
Class C Apartments, Hotels	Good	55
	Medium	50
	Poor	45
Hotel, Residence	Good	60
	Medium	55
	Poor	50
Store, Lofts, Garage	Good	60
	Medium	55
	Poor	50
Factory	Good	45
	Medium	40
	Poor	35
Warehouse, Church	Good	65
	Medium	60
	Poor	55
School, Theater	Good	50
	Medium	45
	Poor	40
Class A. Fireproof	Good	90
	Medium	82.5
	Poor	75

Any one who has resided in the older sections of New England, New York and Pennsylvania knows of scores of frame buildings, to say nothing of stone or brick buildings, that have passed the century mark and are still used as habitations. Europe is full of such buildings centuries old.

If it be claimed that the published lives of buildings are functional and not natural lives, doubtless there is some evidence to substantiate the claim, but the evidence even of that is far from adequate when used to arrive at "average lives." Nor could it be otherwise, for functional lives of buildings differ widely, not only for different clases of buildings but for different localities.

Lives of buildings all remind us we know next to nothing definite about the subject. Actual inspection and study of each building is necessary in order to estimate its accrued depreciation with much accuracy.

EDITORIAL COMMENTS.

Prof. E. W. Bemis continues his profitable career of showing municipalities how to crowd public utilities to the wall. His latest triumph is in Dallas, Texas. He has framed a "model franchise" limiting the street railway company to 6 per cent net on a valuation of 70 ct. on the dollar claimed as a fair value by the company. The voters of Dallas are soon to vote on the franchise. Consider the travesty of leaving a question of that sort to a public vote, particularly a vote by people directly interested in having rates as low as possible! As well ask school children to decide whether the corner peanut vender should be compelled to reduce his price from a nickel to three cents a bag.

Public regulation of utilities is entering upon a critical period. Valuation engineers and rate experts are graduating from the offices of commissions and consulting engineers by the score. Some of these young men, in eagerness for employment, are writing to city mayors and councils offering their services, the payment therefor to be contingent upon their success in effecting reductions in the rates charged by electric light, gas and water companies. This is an application of the economic law of "payment proportionate to performance" that may well cause blindfolded Justice to snatch the bandage from her eyes.

Recently there has been considerable agitation as to the desirability of mixing concrete longer than a minute. There has been somewhat a plethora of talk and a paucity of tests to prove the advisability of long mixing. Mr. William D. Uhler, chief engineer, Pennsylvania State Highway Dept., recently gave the results of an 8-day test on the compressive strength of 6-in. concrete cubes, mixed various lengths of time in a mixer making 17 revolutions per minute. The results were:

Time, min.	Lbs. per sq. in.
0.5	1,400
1.0	1,587
1.5	1,926
2.0	1,661
3.0	1,673

It is anomalous that a three-minute mix gave less strength than a mix half as long. These data are more suggestive than conclusive.

What engineer designed the first steel-skeleton office building? A cursory research of structural literature fails to disclose mention of the name of the inventor of the modern "skyscraper." The first passenger elevator is said to have been installed in 1859 in the Fifth Avenue Hotel, New York. In 1869 the Equitable Building became an object of interest because it contained a battery of elevators.

THE VALUATION OF WATER WORKS PROPERTIES.

XI.—Some Disputed Points in Water Works Valuation.

By Halbert P. Gillette.

The decisions of courts and public service commissions vary so greatly on many points involved in water works appraisals that, at first sight, there seems to be no possible means of reconciling the divergencies of view. One or two of the commonest cases will illustrate the point.

Very often it happens that water mains were laid prior to the construction of permanent pavement in the street. When this is the case, obviously the water company has expended no money in laying pavements and therefore its actual ledger costs of plant do not include this item. But if an appraisal is made of the property on the theory of the "reproduction cost," it is usual to assume that the problem of the appraiser is to find the cost of building a similar water plant under the existing conditions, not as they were when the plant was built, but as they exist at the time of the appraisal. In that event the appraiser commonly estimates the cost of digging up the existing pavement, of trenching for the pipes, laying the pipes, backfilling and relaying the pavement. Since the cost of excavating a pavement is commonly estimated at $1 a square yard and since the cost of relaying a pavement is seldom less than $2 a square yard, it is evident that this item of pavement over mains becomes a very substantial part of the total cost of reproduction; but the question is then raised whether a water company is entitled to an appraisal that includes work which it, as a company, never did perform. The Wisconsin Railroad Commission and many other commissions have replied in the negative. On the other hand, the United States Supreme Court, in what is called the Consolidated Gas case, New York City, decided in the affirmative.

It frequently happens that water companies charge their customers for making service connections, even including a charge for that part of the service pipe that lies beyond the property lines of the customer. The company has a franchise under which it is empowered to lay pipes in the streets. Since the customer has no such authority, he cannot claim ownership in any of the service pipe that he has paid for excepting that part that lies upon his own real estate. The question then arises whether the water company is entitled to have an appraisal that shall include service connections paid for by the customer, but lying outside of the customer's property line. This question is usually decided by commissions in the negative. Nevertheless it is fairly open to debate.

The foregoing two disputed points are typical of numerous others. A classification of nearly all such points in dispute discloses that by far the larger part of them may be thrown under one or two general heads. For brevity we may call one of these heads "The Agency Theory," and the other head may be called the "Competitive Theory."

Under the "agency theory" it may be assumed that the public utility company acted as an agent of the public and, as such agent, was entitled to credit in its plant construction only for the money actually paid out by the company. It is evident that this theory of appraisal of the property of a public utility is equivalent to ascertaining the actual cost of its property as nearly as may be determined.

Under the "competitive theory," however, the actual cost is used in no way except to indicate what it would cost to produce or reproduce a replica of the existing property under the conditons existing at the time of the appraisal. This is a theory upon which most commercial appraisals would be based if one were asked to arrive at the "physical value" of a given plant. The competitive theory, therefore, is less a cost theory than it is a theory of value. If carried to its logical conclusion the competitive theory involves estimating not the cost of reproducing the actual plant as it stands, but of producing the most economical plant that could be substituted for the existing plant and perform the same service.

A study of the decisions, particularly the recent decisions of the public utility commissions, indicates that most of these commissions lean toward the agency theory. On the other hand, a study of the decisions of the United States Supreme Court and of most of the federal and state courts shows a tendency to lean toward the competitive theory. But, holding these two theories clearly in mind, it is possible for the appraiser at least to be consistent and certainly to work toward a definite goal in the formulation of his theories regarding the proper methods of arriving at an appraised value.

If, as often happens, a water company has secured water rights in the early days of its existence at a comparatively nominal cost, then the agency theory would assign to the company a value of those water rights corresponding to that original cost, whereas the competitive theory would assign a value based upon the costs of securing equivalent rights as of the time of the appraisal.

The laying of pipes in small jobs is considerably more expensive than where the jobs are large, the reasons being obvious. Most water companies' plants have been built in relatively small extensions from some original nucleus, and consequently the labor cost has been greater than if the plant were built as a whole. Piecemeal construction, as this sort of work is called, implies higher unit prices than wholesale construction. An appraiser working under the agency theory would use piecemeal prices, whereas an appraiser working under the competitive or reproduction cost theory would use wholesale prices. Freight rates on less than carload lots of course are higher than on carload lots, likewise costs of haulage are greater for small quantities than for large quantities, and many other similar items enter into an increase in unit prices for piecemeal construction.

Another disputed point is whether the prices for materials and labor existing at the time of the appraisal should be used or whether average prices extending over a term of years should be used. The answer to this question likewise depends upon the fundamental theory on which the appraisal is based. Average prices of course would be associated with the agency theory, whereas present existing prices would be associated with the competitive theory. In the case of cast-iron pipe, this becomes a very important item of difference due to the wide fluctuation that occurs in the price of pipe.

In a recent appraisal, upon which the writer was engaged, there was a considerable dispute among the three appraisers who were acting as arbitrators as to whether a standpipe which was surrounded with masonry should be valued in accordance with the existing design, which was antiquated, or whether a modern standpipe, either steel or concrete, should be used as a criterion of value of the existing standpipe. Of course, the real answer to this question had to be based upon which of the two theories of appraisal was to be assumed as most equitable.

Another point of dispute that frequently arises is whether the full value of an existing pipe system should be allowed if the pipe is too small to give adequate fire service. With this problem, of course, is involved the whole question of depreciation which has already been discussed in the second paper of this series. If the reader will refer to that paper, he will find what is there termed "functional depreciation" is closely to be associated with the competitive theory of appraisals, whereas the agency theory, strictly speaking, is not concerned at all with functional depreciation and should be confined entirely to natural depreciation.

As already indicated in the fifth article of this series, there is a wide divergence of opinion as to the proper method of appraising the so-called non-physical values under the various terms—going value, development cost, etc. Reference to that paper will likewise show that the agency theory and the competitive theory must be clearly held in mind in order to arrive at a consistent method of appraising non-physical values. The agency theory is associated with "development cost" (or "going value," as it is termed by the Wisconsin Commission), and the competitive theory is associated with the "franchise value" or the commercial value of the going concern.

The foregoing brief summary of some of the disputed points in water works appraisals, together with a re-examination of the preceding articles above mentioned, will make it very clear, I think, that before an appraiser enters upon his problem he must set down definitely which of the two fundamental theories he proposes to adopt or whether he intends to make an appraisal under each of the two separate theories and then effect certain compromises between them in coming to his final conclusion. I am inclined to think that the method of compromise is at present the only feasible method, for to a certain extent all public utilities have been agents of the public and to a certain extent they have really been free agents acting under competitive conditions. As a matter of equity, then, it must be ascertained to what extent they have been agents and to what extent they have not been agents. This, it is true, presents a problem that is often exceedingly complex, but the complexity alone should not excuse an appraiser, or a commission, or a court, from ascertaining all the underlying facts. There is manifest injustice in denying to a successful company any "franchise value" when that company has had to operate without any particular protection or assistance from the public. Having faced all the vicissitudes of a business career and having ultimately arrived at a profitable period, it is certainly inequitable to deny to the managers and owners of such a company a reward for their perseverance and ability. Conversely, when a company has had an exclusive franchise, has in nowise suffered from severe requirements on the part of the public and has enjoyed prosperity from its very inception, it would be unjust in most cases to capitalize any high net earnings that may exist at the time of the appraisal and to call its capitalization the value for rate-making purposes. Somewhere between the extremes lies the true mean that the appraiser must ordinarily seek.

After a utility company has come under the jurisdiction of a commission and its property has once been appraised, it seems equitable that its actual investment should become the base upon which a rate of fair return should be calculated. Even then, however, a farsighted commission will grant more than normal rate of return, provided there is evidence of aggressive and intelligent management.

A NEW PENETRATION NEEDLE FOR USE IN TESTING BITUMINOUS MATERIALS.*

By C. S. Reeve and F. P. Pritchard, Office of Public Roads and Rural Engineering, Washington, D. C.

As the result of a series of tests on the uniformity of standard parabola sharp No. 2 needles and to determine a form of needle possible to define accurately the following conclusions are offered.

(1) The No. 2 sewing needle which has heretofore been used for the penetration test can not be taken indiscriminatly, but must be carefully selected and standardized.

(2) There is no recognized established standard with which new needles can be compared, and that it is not feasible to accurately describe the dimensions of a parabola needle.

(3) The so-called standard needles furnished with penetration machines may vary among themselves.

(4) The writers have designed a needle which gives results in close accord with existing standards and has, moreover, the advantage of being accurately described and easily reproduced.

(5) The needle is made by placing a 2-in. length of 0.041-in. annealed-steel drill rod in the chuck of a high-speed lathe, and by means of a fine sharp file turning the end to a sharp point having a ¼-in. taper. When it has been made as smooth and sharp as possible by this means, the needle is tempered, then ground to a sharp point with a good stone, after which it is smoothed and polished with emery dust, crocus cloth, and rouge, and finally held carefully on a buffing wheel. The finished needle should be sufficiently smooth and sharp to enter and pass through a piece of ordinary writing paper without sticking or friction. In other words, this new needle must have as sharp a point and smooth a surface as any sewing needle. The important thing is to have the taper straight, beginning ¼ in. from the end, and the needle above the taper exactly 0.04 in. in diameter.

EXPERIENCE WITH BITUMEN CARPETED CONCRETE PAVEMENT IN ANN ARBOR, MICH.*

By Manly Osgood, City Engineer.

Oftentimes our most valuable lessons are learned from mistakes, whether made by ourselves or by others. This happens to be the case in the subject which I will present to you today. It would be far more pleasant from all viewpoints to tell you of some paving which had been very successful, but if mistakes were always concealed our profession would not be able to boast of so many great achievements.

My paper will treat almost entirely of the more or less familiar Ann Arbor tarred concrete pavement. This is a concrete pavement, usually laid in two courses, with a carpet coating of tar and sand placed as soon as the concrete is sufficiently cured. This type of pavement originated in Ann Arbor in a peculiar way. In 1907, during the construction of a new City Hall, a barrel of tar was accidentally spilled over a concrete walk. Sand was thrown into the tar to make the walk fit for foot traffic. The tar and sand adhered to the concrete and the carpeting thus formed is intact today. This accident furnished the idea for the carpeted pavement, the first of which was constructed in 1909. The above incident happened considerably prior to my connection with the city of Ann Arbor, but has been related to me by other officers who were there at the time. The first pavement of this type was constructed on Maynard St., is one block long, and contains 1,880 sq. yds. The materials were purchased and the work of construction was done by the city, and every precaution was taken to insure good results with the materials used. This pavement was laid for $1.03 per square yard, including curbing and grading, or for 78 ct. per square yard for the pavement only. It had been comparatively difficult to obtain the necessary majority signatures for a pavement on Maynard St., but when the news was spread that this pavement had been constructed so cheaply the petitions commenced pouring into the Common Council from all parts of the city and all expressed a preference for "pavement similar to that on Maynard St." The result was that the city started paving streets as fast as was possible with the machinery and labor available. This can best be illustrated by the yardages laid during the succeeding years:

	Sq. yd
Laid in 1909	1,880
Laid in 1910	16,560
Laid in 1911	64,090
Laid in 1912	11,540
Laid in 1913	33,460
Laid in 1914	11,830

The drop in 1912 was due principally to water works agitation which developed that year, and perhaps secondarily to the fact that it was in that year that a change was made in the City Engineer's office. I assumed the office of City Engineer on June 17, 1912, coming from an Ohio city and having no assistants who held over from the previous administration. The drop in 1914 was due to a charter clause which provides that not more than $150,000 worth of paving bonds shall be outstanding at any time. This limit was reached in 1914 and now only so much paving may be done each year as will require a bond issue equal to those redeemed the previous year.

It was in 1910 that two things transpired that worked seriously to the detriment of the pavement laid that year and in 1911, which constitutes about 58 per cent of all of this type of pavement now in the city. Bids were called for and received, but the City Council, on the advice of their officers, rejected all bids and ordered these officers to proceed with the construction on a force account basis. The specifications under which bids were received called for a 5-in. lower course and a 2-in. top course of concrete. In order to insure a substantial saving in cost over the lowest bid received, the lower course was made $4\frac{1}{2}$ in. thick and the top course $1\frac{1}{2}$ in. thick, a total thickness of 6 in. instead of 7 in. In 1910, also, a patent was applied for, a company organized and this type of pavement was advertised and promoted throughout the country. Low first cost was the most advertised feature and the results obtained at Ann Arbor were used as examples of remarkable savings. The application for patent, which was never granted by the United States, was made by a city employe with much authority in paving construction and, as he received a royalty on every yard of this type of pavement licensed or constructed by the company promoting it, he was very materially interested.

---

*Extract from report from Journal of Agricultural Research, March 13, 1916.

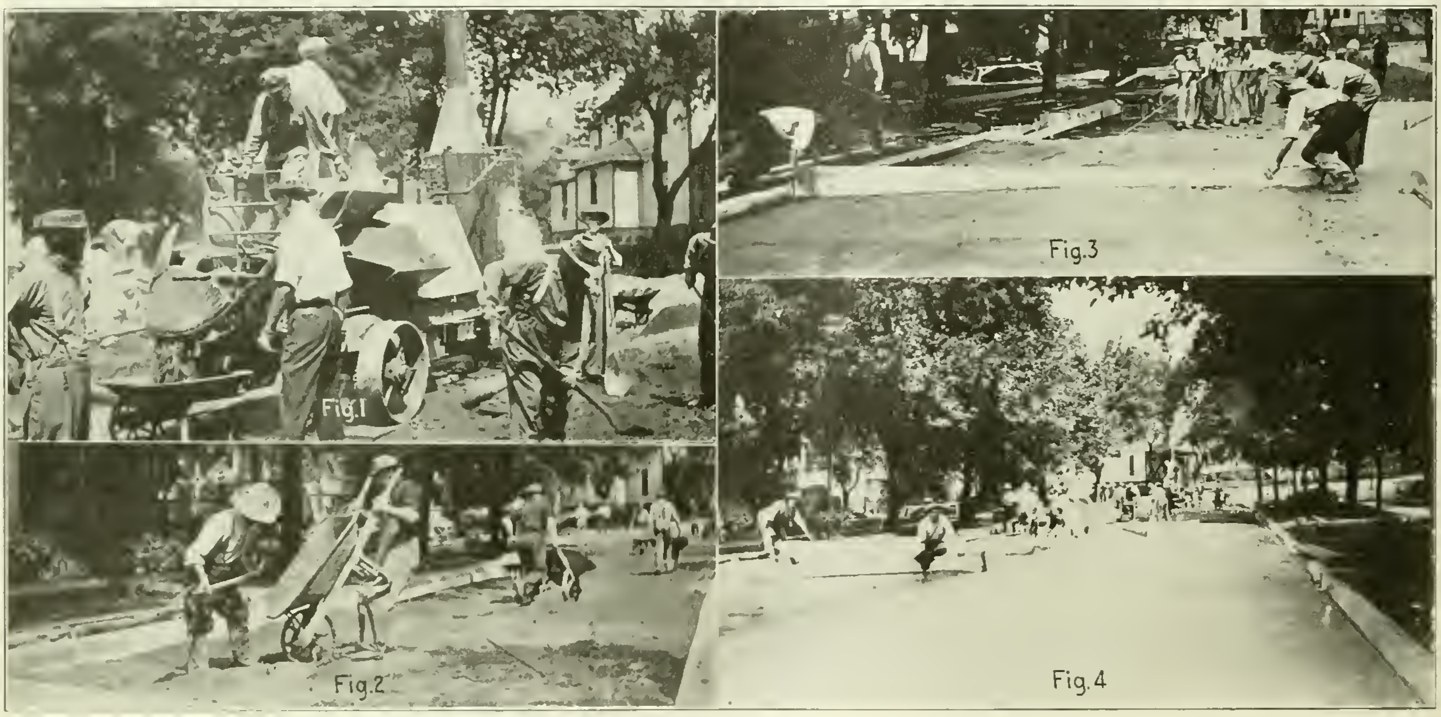
*Paper read at the annual meeting of the Michigan Engineering Society.

In these two years, 1910 and 1911, everything was sacrificed to first cost. The small batch concrete mixer used on Maynard St. was replaced by continuous mixers of greater capacity. Cement was never tested unless some reason was very evident to suspect that it did not come up to specifications. Bank run gravel was used in both courses without screening or washing, and, especially in 1911 when the greatest yardage was laid, there was not sufficient or sufficiently competent supervision or inspection to insure even the best obtainable bank run gravel. Many who are familiar with the paving operation that year have told of seeing lumps of clay or even of sod in the gravel as it lay ready to be shoveled into the mixer. On one occasion, three blocks long of a comparatively heavy traveled street with a car track in the center, a further saving was effected by building a one-course concrete pavement of one part cement to five parts of this same bank run gravel. And after the pavement was entirely completed, not before, the number of sacks of cement used was checked against the yardage and it was found that not sufficient cement had been used to make even a one to five mixture. I must say right here that although this section of pavement was constructed in 1911, the city is now facing the proposition of surfacing it with some stable material or reconstructing it. The carpet coating will not adhere to this lean mixture.

No reinforcing of any type was placed in these concrete pavements, nor were the expansion joints protected in any way. Care was not taken to see that these joints were opened and clean to the full depth of the pavement, but sweepings from the concrete prior to carpeting were brushed into them and the remainder of the joint filled with tar and sand poured separately.

In 1912 the thickness of the pavement was increased to 7 in. with a 5-in. lower course and a 2-in. upper course and care was taken to insure the best grade of bank gravel obtainable. In 1913 we commenced using a washed and screened sand in the top course, retaining the bank gravel for the lower course. Care was also taken to have an open expansion joint the full depth of the concrete and these joints were filled with filler asphalt.

Many experiments were made to determine the best bituminous material for the carpet coating. Bermudez asphalt was tried, but in the winter time became brittle and scaled from the concrete. All grades of coal tar were tested from the crude product to that with considerable refining. The results indicated that the coal tar product with only sufficient refining to drive off the water and lighter oils were best adapted to the conditions in Ann Arbor. The crude tar was purchased at the local gas plant and sufficient refining given it by heating to about 220° F. to 250° F. as it was applied to the concrete. During 1911 a bitumen was purchased from the Barrett Mfg. Co. with about the same amount of refining as their lightest grade of Tarvia, but showed no better results than was attained by using the local tar refined as above described. Various methods of application were tried. At one time the only sweeping was done with a rotary broom. This was followed with a gravity tar spreader which in turn was followed with an automatic sand distributor. At another time the pavement was swept by hand, the tar applied with pouring pots and squegees and the sand spread with shovels. Various combinations of hand and machine work were used. The tar and sand was even applied to the concrete surface after sprinkling with water. The results obtained indicate that the surface to be carpeted should be thoroughly dry and free from dust and that the tar should be applied sufficiently hot to be in a thoroughly liquid state. Whether the tar and sand are applied by machine or by hand does not affect its lasting qualities so much as does the temperature of the concrete to which it is applied. The carpeting should be applied during hot, dry weather. A one-size



TAR CARPETED CONCRETE PAVEMENT IN ANN ARBOR, MICH.
Fig. 1. Mixer and Mixing Gang.—Fig. 2. Wheeling and Spreading Concrete.—Fig. 3. Shaping Concrete With Templet.—Fig. 4. Finishing Concrete Surface.

TABLE 1.—SUMMARY OF PAVEMENTS IN THE CITY OF ANN ARBOR.

Dist. No.	Street.	When laid.	No. sq. yd.	Total cost.	Total cost per sq. yd.	Cost per sq. yd., pavement only.	**Kind.**
1-2.	Main	1898	12,730	$31,375.15	$2.46	$1.64	Brick on concrete.
3.	Washington, Ashley to 5th Ave	1899	5,140	11,645.17	2.27	1.73	Brick on concrete.
4.	Huron, Ashley to State	1900	10,791	27,845.38	2.58	2.17	Asphalt block on sand.
5.	State, Huron to Monroe	1902	12,484	31,778.98	2.55	2.16	Asphalt block on sand.
6.	Ann, Main to 4th Ave	1902	1,589	2,860.70	1.80	1.39	Brick on sand.
7.	Liberty, Ashley to State	1903	9,140	24,486.06	2.68	2.19	Asphalt block on sand.
8.	Fourth Ave., Huron to Liberty	1903	2,431	6,490.80	2.67	2.19	Asphalt block on sand.
9.	William	1907	7,519	19,092.01	2.54	2.03	Bitulithic.
10.	N. University	1905	5,045	10,720.16	2.03	1.63	Brick on concrete.
11.	Alley	1908	350	672.74	1.92	1.50	Brick on concrete.
12.	Maynard	1909	1,883	1,930.13	1.03	.78	Ann Arbor tar-concrete.
13.	N. Fourth Ave., Huron to Ann	1910	1,159	1,351.34	1.17	.88	Ann Arbor tar-concrete.
14.	E. Huron and Twelfth	1910	6,765	6,685.50	.99	.76	Ann Arbor tar-concrete.
15.	Washington, 5th Ave. to 12th	1910	8,633	8,189.73	.95	.71	Ann Arbor tar-concrete.
16.	Washtenaw Ave.	1911	12,092	12,392.81	1.03	.78	Ann Arbor tar-concrete.
17.	State, Packard to Arch	1911	2,587	2,672.49	1.03	.84	Ann Arbor tar-concrete.
18.	S. Main and Packard	1911	20,826	23,172.05	1.11	.78	Ann Arbor tar-concrete.
19.	N. Main, Catherine St. north	1911	10,117	11,110.86	1.10	.82	Ann Arbor tar-concrete.
20.	Hill and Oswego	1913	5,682	7,726.41	1.36	.93	Ann Arbor tar-concrete.
21.	Fifth Ave.	1911	10,483	11,678.31	1.12	.84	Ann Arbor tar-concrete.
22.	Alley	1911	293	314.84	1.07	.84	Ann Arbor tar-concrete.
23.	Alley	1911	920	1,029.38	1.12	.77	Ann Arbor tar-concrete.
24.	Arch and Thayer	1911	1,833	1,747.35	.95	.77	Ann Arbor tar-concrete.
25.	State, Monroe to Packard	1911	3,158	3,181.57	1.01	.78	Ann Arbor tar-concrete.
26.	Mary	1912	2,407	2,703.08	1.12	.89	Ann Arbor tar-concrete.
27.	Ashley	1912	7,711	9,071.92	1.18	.91	Ann Arbor tar-concrete.
28.	W. Liberty St., Ashley to city limits	1913	15,612	20,836.90	1.34	.98	Ann Arbor tar-concrete.
29.	W. Huron St., Ashley to Forks	1913	14,131	19,257.61	1.36	1.01	Ann Arbor tar-concrete.
30.	Church St., Washtenaw to Prospect	1914	11,832	14,802.93	1.25	.98	Ann Arbor tar-concrete
31.	Hill St., State St. to Washtenaw Av			Not completed.			
32.	Ann St., Main St. to First St	1915	2,085	2,740.80	1.33	1.02	Reinforced concrete.
33.	Jefferson St., Fifth Ave. to State St	1915	4,924.2	8,665.40	1.62	1.30	Asphaltic concrete.
34.	Division St., Detroit to Packard	1915	14,372.5	24,733.97	1.60	1.29	Asphaltic concrete
35.	Geddes Ave., Oxford to Oswego	1915	3,273.0	5,431.55	1.66	1.19	Reinforced concrete.

gravel screening, between the one-eighth and one-quarter inch screens gives better results than was obtained with other sands and gravels tried.

The distance between transverse expansion joints was varied from 25 to 50 ft. The longer blocks developed a transverse crack approximately in the center. A spacing of 30 ft. between these joints was found to give the best results.

As I said before, after the completion of Maynard St., the people of Ann Arbor were very enthusiastic about this type of pavement. It continued to grow in favor during 1910 and 1911. Then the tide commenced very slowly to turn. It became evident to all that it would be necessary to recarpet the concrete every two or three years and in some cases probably every year, varying with traffic conditions. Those who owned automobiles did not like the throwing up of tar and sand onto the under sides of the fenders. Owners of horse drawn vehicles avoided the newly carpeted streets and even pedestrians avoided the crossings. In some places where the carpeting peeled the concrete commenced to ravel and sections varying in size had to be cut out and replaced with better material. Then the one course concrete section previously mentioned wore away rapidly and two other streets laid the same year showed evidence of soon needing extensive repairs. A majority of the people now realize that reducing the first cost to a minimum together with insufficient inspection has imposed a heavy burden on the community in the expense of maintenance, repair and reconstruction. These pavements must be kept carpeted to preserve the concrete underneath as long as possible and for some years to come the citizens will have the annoyance of freshly tarred streets.

But this type of pavement did do one real good to the city of Ann Arbor. Prior to 1909, there were only 67,220 sq. yd. of pavement laid and property owners could not be persuaded to petition for more on account of the cost. In the two years following the completion of Maynard St. petitions were received for more than 200,000 sq. yd., some of which is not yet constructed and cannot, unless the Charter limitation previously mentioned should be changed for two or three years. The introduction of this type of pavement, cheap in first cost, hastened the construction of sufficient pavement to make the property owners realize the economic value of the paved street. Now they are still petitioning for pavements even though they realize that the first cost will be somewhat higher than was the cost of the tarred concrete pavements. Furthermore we would not have even the 231,000 yd. of paving which we now have had it not been for the cheapness of the first cost of a majority of it.

The carpet coating of tar and sand has been put to other use in Ann Arbor than covering concrete. During the years from 1900 to 1903, a total of 32,500 sq. yd. of asphalt block pavement was laid on some of the heaviest traveled streets in the city with no other foundation than the compacted gravel soil. As early as 1908 it was realized that some measure must be adopted to preserve this pavement and it was given such a carpeting. The success of this carpeting strengthened the faith in a carpeted concrete pavement, the idea for which had been conceived the previous year. The tar and sand adheres very well to the asphaltic surface of these block paved streets and the use of this carpeting has prolonged the life of these pavements for many years. On these streets, one such coating lasts for about four years. It need hardly be said here that Ann Arbor learned also that any necessary patching of a pavement was most effectively done with the same material as the pavement patched. The repairing of asphalt block streets with vitrified brick or concrete patches was an absolute failure.

Returning again to the carpeted concrete pavements, let me summarize for you the advantages and disadvantages of such a pavement, provided the construction work is done in the best possible manner. The cost of the coating of tar and sand just about offsets the coat of reinforcing and joint protection which would be necessary if the concrete were not to be kept protected by the carpeting. This carpeting waterproofs the surface and makes it less absorptive, therefore more sanitary. It also deadens the sound made by horses hoofs on the unprotected concrete and does away with any sun-glare from uncolored concrete. The disadvantages, which are due to the fact that the carpeting does not adhere well to the concrete, are the expensive maintenance and the annoyance of freshly tarred streets every summer.

In conclusion allow me to say that I think Ann Arbor has learned its lesson. Concrete pavements, as a class, are not condemned, in fact about 5,350 sq. yd. of reinforced concrete pavement was included in that constructed during the past summer. But the gravel used was washed and screened and remixed in a batch mixer and every precaution was taken to insure the best materials and proper construction. The property owners in most cases are now willing to have the type of pavement to be constructed decided upon a sound engineering basis, but in whatever type is constructed, they want only first class materials and first class work. I think we may safely say that Ann Arbor has returned to good standard engineering practice in the construction of pavements.

Records of repairs to asphalt streets, of standard construction in Norfolk, Va., with and without street car tracks, indicate a deterioration of 30 per cent for the former as against 2½ per cent for the latter in the same length of time.

COMMON ABUSES THAT SHORTEN THE LIFE OF MOTOR TRUCK TIRES.

Contributed by A. H. Leavitt, Assistant Manager Truck Tire Sales, B. F. Goodrich Co., Akron, O.

Tires, however well designed and however well adapted to the contractor's hardest truck service, are everywhere falling short of attaining the goal of 100 per cent profit-making ability because of abuse to which they are subjected. Some of these abuses are legitimate, most are not. The most important of these tire life-shortening abuses are here briefly discussed. It is well that every contractor interested in getting the most mileage and service from his tires familiarize himself with means of prevention of these abuses.

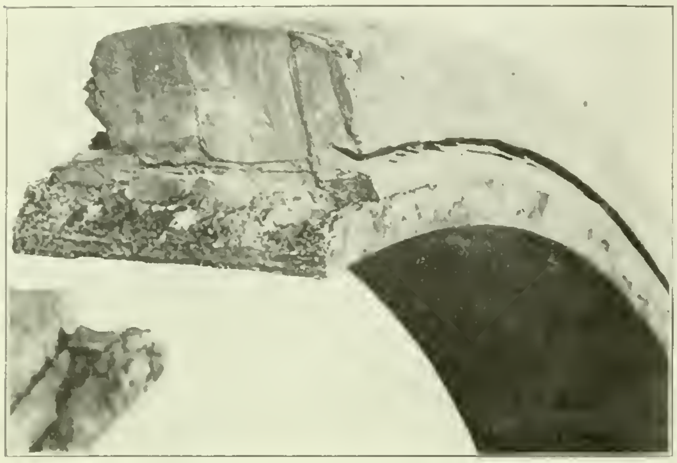


Fig. 1—Tire Broken by Heavy Loading.

Overloading.—The dangerous effect of overloading cannot be over-estimated. Tires are constructed to carry certain loads, wihich if exceeded, will result in premature failure of the tire units. Rubber compressed beyond its safe limit of elasticity, will break down (Fig. 1) just as any other material will do. Rubber compressed to such a limit, is also much more susceptible to damage from road obstacles. Continued overloading is not required to ruin a tire, as one excessive load or a blow developing equivalent force from high speed may do it, and a permanent rupture to the structure is likely to follow. Avoidance of overload and proper care of tires are of first importance in the economy of operation.

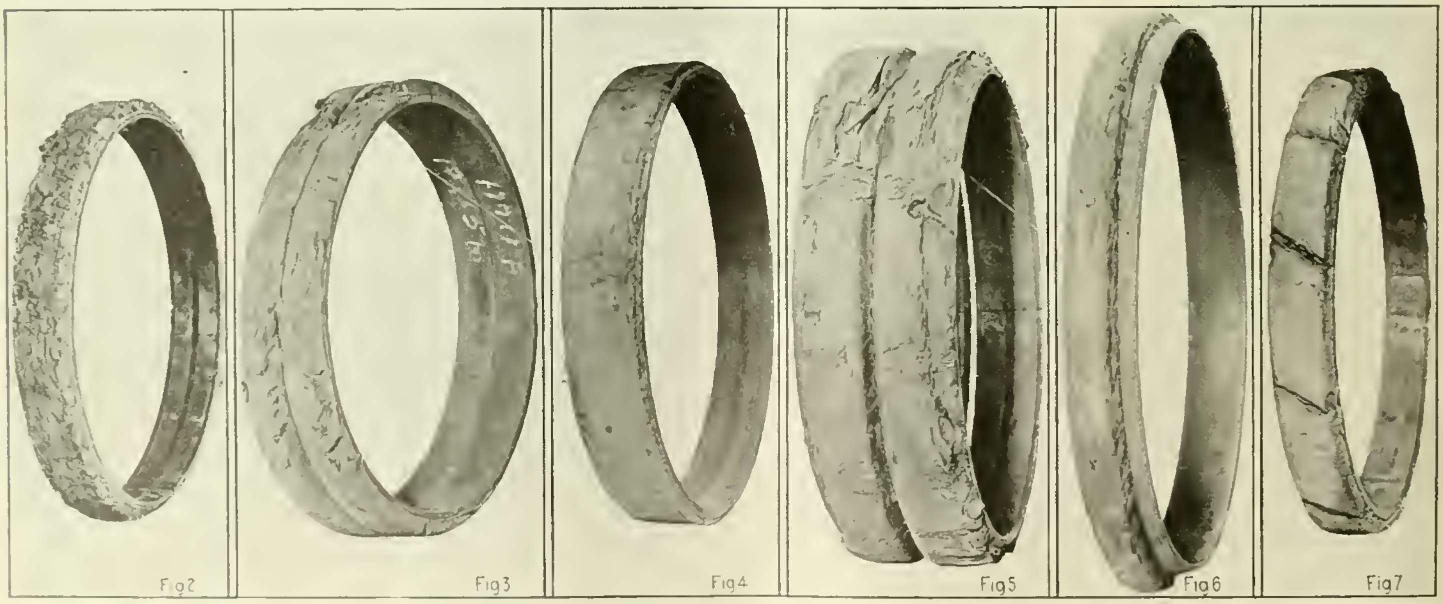


Fig. 2—Tire Injured by Speeding. Fig. 3—Tire Injured by Skidding. Fig. 4—Tire Injured by Wheels Being Out of Alignment. Fig. 5—Tire Injured by Neglected Cuts. Fig. 6—Tire Injured by Car Tracking. Fig. 7—Tire Injured by Non-Skid Devices.

Speeding.—In a tire injured through over-speeding Fig. 2, the results are similar to the injuries resulting from overloading. The effect of heat generated within the tire, due to rapid displacement and road friction, is too well known to require further comment. When striking obstacles at high speed, the possibility of rupture is much increased.

Skidding.—Skidding or locking the brakes and sliding the wheels results in serious and most uncalled for damage. This has a ruinous effect on the mechanism of the truck, as well as causing great damage to the tread of the tire. The tire illustrated, Fig. 3, was practically new; the tread was completely torn away for a short distance, as a result of skidding. It is a matter of fact that a truck will not stop as quickly by sudden application of the brakes, as when improperly adjusted brakes permit one wheel to lock while the other runs freely. This same condition is also found on equipment which turns corners at a high speed. This naturally increases the side strain and wear on the tires.

Bad Roads.—One of the elements most destructive to solid tires is bad roads. Regardless of any precaution which might be taken in respect of overloading, excessive speeding, etc., if a loaded truck is habitually used over bad roads, the tires receive abuse such as will materially affect their life.

Wheels Out of Alignment.—The tire illustrated, Fig. 4, looks as if it had been worn down perfectly smooth in service, but as a matter of fact, it only gave a few hundred miles of service. The cause of this quick wearing was due to one of the wheels of the truck being out of alignment. The effect of the truck, when a wheel is out of alignment, is that of continual friction, as the wheel partly rolls and partly slides. Wheels should be inspected often, and when this condition is found, immediate steps should be taken to remedy it.

Neglected Cuts.—Cuts on solid tires are more or less a common occurrence. This is, of course, governed largely by the road conditions. The ultimate effect of a cut depends upon the size and location, as cuts near and at the edge are most injurious and if neglected may seriously affect the life of the tire, as the tendency is always toward the cut enlarging, especially in circumferential direction. Some trucks are backed up a great deal and the cut consequently enlarges both ways from the injury. The weakening of one unit of a dual tire in this manner naturally throws an overload on its mate at the point of injury, which may cause it to fall, as in this case, Fig. 5. To prevent the continuation of a cut on the edge it should be trimmed.

Car Tracking.—It is common to see not only the motor truck driver, but also the horse truck driver, proceeding down the street with all wheels of the truck or wagon in the car tracks. It is unquestionably much more comfortable to ride in the car tracks on some streets than it would be on the streets themselves. However, the results of running solid tires on car tracks are disastrous. The entire load is thrown onto one-half of the tire tread, with the result that it is rapidly worn or broken away, Fig. 6, on one side, eventually leaving the width of the tire reduced by one-half to carry the original full load.

Non-Skid Devices.—Another of the accompanying illustrations, Fig. 7, shows the injuries resulting from the use of anti-skid devices, which were improperly applied. Unfortunately, we know of no auto-skid device that does not, to some extent, injure solid tires. Some devices are more injurious than others. The loose chain has been found the least so because it works itself around the wheel and provides an equal distribution of the wear and strain. Stationary devices are most injurious, because the wear and strain are constantly confined to the points of bearing.

Chains of various designs which pass circumferentially around the wheel and between dual tires place a strain on the tire base and are generally ineffective because dependent upon the compression of the tire tread to allow the device to secure traction.

The traction wheels are liable to spin more or less in slippery places,which produces a sharp blow on the tires where these devices are in contact. The force of such blows increase as the distance between the cross pieces of the device increases, because of the momentum the wheel gains between these points. Less injury will result if such devices are only used temporarily. It is also advisable to use a device having numerous cross pieces.

Great injury results to tires from careless and continued use of anti-skid devices on pavements or hard roads where there is little or no need for them.

ESTIMATING QUANTITY OF GROUND WATER IN DESIGNING MILWAUKEE'S INTERCEPTING SEWERS.*

By Carl H. Nordell, Engineer of Designs, Milwaukee Sewerage Commission.

In estimating the quantity of sewage to be provided for in the intercepting sewer system and sewage treatment works at Milwaukee, the sewers have been designed to carry off the maximum amount of ground water reaching them in addition to the domestic, commercial and industrial run-off.

To determine the maximum amount of ground water to be expected the current meter sewer gagings made have been used. These were made after a period of heavy rains, when the ground was known to be saturated with water, thus furnishing an exceptionally good opportunity to obtain data. It is assumed that the water flowing during the time of minimum flow, which occurred during the early hours of the morning, was all ground water. As these were all typical residential districts, which are known to produce only a small amount of sewage at such hours, this assumption is fairly correct.

Districts 53, 54 and 56 gave a minimum flow of 40.7 gal. per capita, the population was 62,000, and the area drained 1,730 acres. We, therefore, get:

$$\frac{40.7 \text{ x } 62{,}000}{1{,}730} = 1{,}460 \text{ gal. per acre per day.}$$

District 36 gave a minimum of 61.0 gal. per capita, the population was 28,515, the area drained 767 acres. Then,

$$\frac{61 \text{ x } 28{,}515}{767} = 2{,}265 \text{ gal. per acre per day.}$$

District 48 gave a minimum of 42 gal. per capita, the population was 38,600, the area drained 1,045 acres. Then,

$$\frac{42 \text{ x } 38{,}600}{1{,}045} = 1{,}550 \text{ gal. per acre per day.}$$

These results may be averaged by giving each a weight equal to the number of acres drained. Thus:

$$\begin{array}{rcrcl} 1{,}730 & \text{x} & 1{,}460 & = & 2{,}526{,}000 \\ 767 & \text{x} & 2{,}265 & = & 1{,}737{,}000 \\ 1{,}045 & \text{x} & 1{,}550 & = & 1{,}620{,}000 \\ \hline 3{,}542 & & & & 5{,}883{,}000 \quad \text{Average } 1{,}660 \text{ gal. per acre.} \end{array}$$

As it is known that this figure errs on the side of safety since all the minimum flow is considered as ground water, 1,620 gal. per acre per day, which is equal to .0025 cu. ft. per second per acre, has been decided upon as the unit to be used in estimating the maximum ground water to be expected.

It is realized that this figure is higher than that generally assumed in cities as ground water run-off, but it is believed to rest upon data that cannot well be controverted. A possible explanation of the high run-off is afforded by the inspection of a number of the old sewers which proved to be in poor condition and leaking badly.

The average rate of ground water run-off is not so high. The gagings made in District 48 in January, indicate that at that time the ground water flow is less than ⅔ of the maximum and the figures for June were but little over ⅔. It is therefore highly probable that the conditions indicated by the gagings in April continue for only a short time during the year and possibly do not occur every year as the spring of 1914 was unusually rainy; it has accordingly seemed reasonable to assume that a figure of ¾ of the maximum ground water flow would represent an average ground water flow which fixes it at 1,200 gal. per acre per day.

---

*From Second Annual Report, Milwaukee Sewerage Commission.

MAINTAINING A LARGE RIVETED STEEL CONDUIT AT PORTLAND, ORE.

The Bull Run Conduit No. 1, of the Portland water works, is 24½ miles long. It was completed in 1894 and consists of 10 miles of 42-in., 7¾ miles of 35-in., and 6½ miles of 33-in. riveted steel pipe.

The metal of which this pipe was made is largely No. 6 BWG plate, or less than ¼-in. thick. The pipe was originally dipped in a preparation of asphalt as a protection against corrosion. It was observed, however, that after the lapse of ten years' time leaks began to occur in certain sections of the pipe due to the pitting of the plates from external corrosion of the metal. These leaks were of small size, not usually exceeding ¼-in. diameter, and were easily and quickly repaired by means of steel plugs driven or screwed into the plates from the outside without having to shut down the flow in the conduit. In a few cases, however, it was necessary to reduce the pressure on the pipe and to make needed repairs by means of a steel band, caulked with lead.

It was soon noticed that these leaks were much more frequent or, it may be said, occurred almost entirely in a heavy clay soil, impervious to water and in locations where provisions had not been made for the drainage of the pipe trenches. Thus in two localities have occurred probably 75 per cent to 90 per cent of all the leaks repaired during the first 20 years the pipe was in service.

It being apparent that the pipe was attacked entirely from the outside it was determined to uncover the sections where the worst conditions prevailed and to clean and paint the outside for the purpose of arresting the corrosion and prolonging the life of the pipe.

The work was completed at an expense of $14,125.16, the work done covering 5,400 ft. of pipe, or an average cost of $2.62 per lineal foot. A large number of pits were plugged where the metal had not been entirely eaten through as a matter of additional insurance. The work has been well done: two, and, in places, three coats of Ferrubron paint having been used after the surface of the plates and all pits had been thoroughly cleaned. This treatment should prolong the life of the pipe for a considerable period. It is estimated that a small outlay each year for work of this character will materially prolong the serviceable life of the conduit.

For the first time in 18 years there was recently completed an examination of the interior of this conduit throughout its entire length. This examination revealed a number of small pit holes at various points, which have been repaired. It also indicated the points where leaks are likely to occur and where the next cleaning and painting work should be undertaken. This examination has also confirmed the opinion previously held that the interior of the pipe is in good condition, not having been corroded in any appreciable degree, and that the asphalt coating still largely adheres to the pipe in a satisfactory manner.

The Portland water works officials are convinced that such pitting of the pipes as has occurred is due to local soil and drainage conditions, and to defective pipe coatings.

SNOW ALARM, OR PREPAREDNESS IN THE REMOVAL OF SNOW.*

By William H. Connell, Chief of Bureau of Highways, Philadelphia, Pa.

The conception and operation of the "snow alarm" in Philadelphia is one of the unique improvements in the Bureau of Highways, which has resulted in greatly benefiting the community. Formerly it was the custom not only in Philadelphia, but in other cities, to wait until the storm was over before beginning the work of removal. In other words, the city did not begin to dig itself out until after the storm had ceased. As a consequence, the traffic was often very seriously congested.

The main idea in a snow removal organization is "preparedness." At any hour of the night, as soon as the snow starts to fall, the Electrical Bureau notifies the Chief of the Bureau of Highways and the engineers in charge by telephone in their respective homes. One engineer living in the central part of the city is in constant communication with the Weather Bureau and the Chief of the Bureau of Highways, and as soon as the indications point to a continuance of the storm, the snow-fighting equipment is ordered out, upwards of about one thousand telephone messages being sent to various parts of the city, calling out squad leaders, inspectors, snow-plows, drivers, teams, laborers, and officers in the various police districts, who aid in getting out the men.

In about one hour after the order is given, the horse-drawn plows and motor-driven plows attack the snow in the central business section of the city. These plows are supplemented by an army of laborers and teams who keep constantly at work day and night shoveling and dumping the snow into sewer manholes and the Delaware and Schuylkill Rivers.

Every man in the snow removal organization has a particular function assigned to him. For instance, each dump inspector knows his post is at a certain dump, and he knows just what to do when he gets there; the driver of every snow plow and every team knows where he is to report, at what point he is to start to load, and at what sewer manhole or wharf he is to dump his loads, and there is no confusion.

Fighting the snow at night during some of the storms we have had in the past three years is no easy task for the Highway Bureau engineers assigned as squad leaders, the inspectors, contractors and the laborers, and it requires the constant presence of the Chief of the Bureau and his principal assistants to encourage the men and stir up the necessary enthusiasm to keep the work going.

In the central business section of the city snow is removed from all the thoroughfares. This work is performed under special contracts supplemented by the regular street cleaning force and is under the supervision of a special snow removal organization made up of men assigned to this work from the regular engineering staff.

Certain main thoroughfares and all the street crossings throughout the entire city are also cleaned by the regular street cleaning forces and a large municipal force assigned to the seven Highway District Engineers who supervise this work. A large force is always employed opening up the country roads, where the drifts often completely block traffic. All told, the force employed on snow removal consists of an army of 4,000 men, 1,200 teams and an advance guard of 38 horse-drawn and 20 motor plows.

---

*Extract from advance sheets of annual report for 1915.

SOME DESIGN FEATURES OF A REINFORCED CONCRETE AND STEEL VIADUCT BETWEEN PORTLAND AND SOUTH PORTLAND, MAINE.

To keep the cost within $1,000,000 the engineers for the new viaduct between Portland and South Portland, Maine, have had to exercise great economy and skill in design. The result is a structure which possesses many different kinds of bridge construction, so blended as to give a pleasing appearance to the entire project. The new viaduct replaces the old Cape Elizabeth bridge and Clark St. viaduct, connecting the two cities, and is being constructed by Cumberland County, assisted by the street railway company, which has two tracks over the viaduct, and by the Portland Terminal Co., which occupies space below it. The viaduct has a total width of 60 ft., and provides a 44-ft. clear roadway and two 8-ft. cantilever sidewalks; the street railway tracks occupy the central 19 ft. of the roadway.

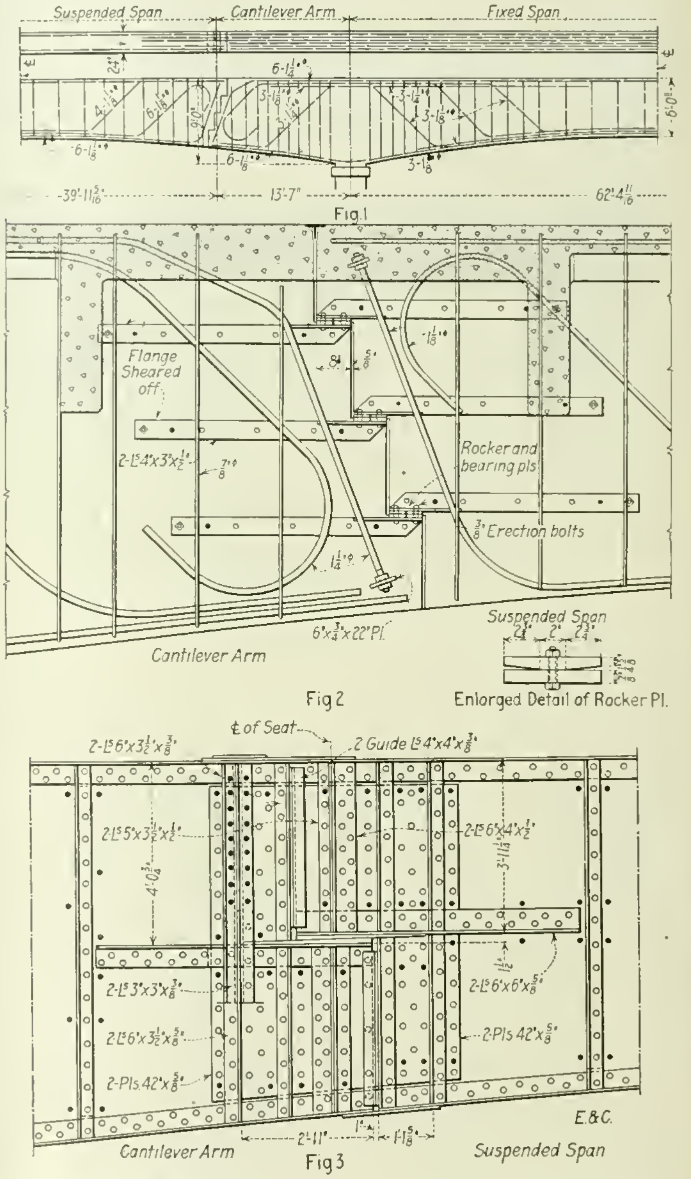


Fig. 1—Half Elevation and Plan of Cantilever and Suspended Concrete Spans and of Adjacent Anchor Span of Portland-South Portland Viaduct, Showing Arrangement of Reinforcement. Fig. 2—Detail of Joint Between a Concrete Cantilever Girder and Its Adjacent Suspended Girder. Fig. 3—Detail of Joint Between a Steel Cantilever Girder and Its Adjacent Suspended Girder.

The viaduct is constructed in six sections. Section 1 is a fill, 62 ft. wide at the top and 875 ft. long, raised to 34 ft. above mean low water. Section 2, which is 275 ft. long, is a fill up to 12 ft. above low water, with a superstructure of reinforced concrete supporting concrete piers resting on wood pile foundations. Section 3 is 1,009 ft. long, and comprises seven plate girder spans, ten piers, two steel truss spans, and a double-leaf Scherzer rolling-lift span. Section 4 consists of a reinforced concrete viaduct 700 ft. long, spanning railroad tracks and a street. Section 5 is a viaduct, which branches from Section 4 and extends 320 ft. to a street at a lower level. Section 6 is also a viaduct, which also branches from Section 4, but extends in an opposite direction to Section 4; it forms an arc of a circle 700 ft. long, part of its width being cut into the hillside and part supported on concrete piers and walls.

For both steel and reinforced concrete spans of the main viaduct a type of construction involving arched cantilever spans supporting suspended spans has been adopted. The seven plate girder spans of this type are each 98 ft. long, the cantilever arms of which each have a length of 16 ft. 4 in., and the suspended spans a length of 65 ft. 4 in. The thirteen reinforced concrete girder spans have lengths varying from 58 to 67 ft.; the cantilever arms of these spans are about 14 ft. long, and suspended spans vary in length from 32 ft. to 40 ft. For each steel span five girders are used, spaced 11 ft. on centers. The reinforced concrete spans each contain six girders, spaced 8 ft. 11⅞ in. on centers. The concrete spans rest on reinforced concrete bents of six columns each, one directly under each girder. The tops of these columns are connected by a cross girder, the bottom of which is curved to form an arch between each pair of columns. The columns rest on a combined concrete footing. The steel spans are supported on steel bents resting on concrete piers.

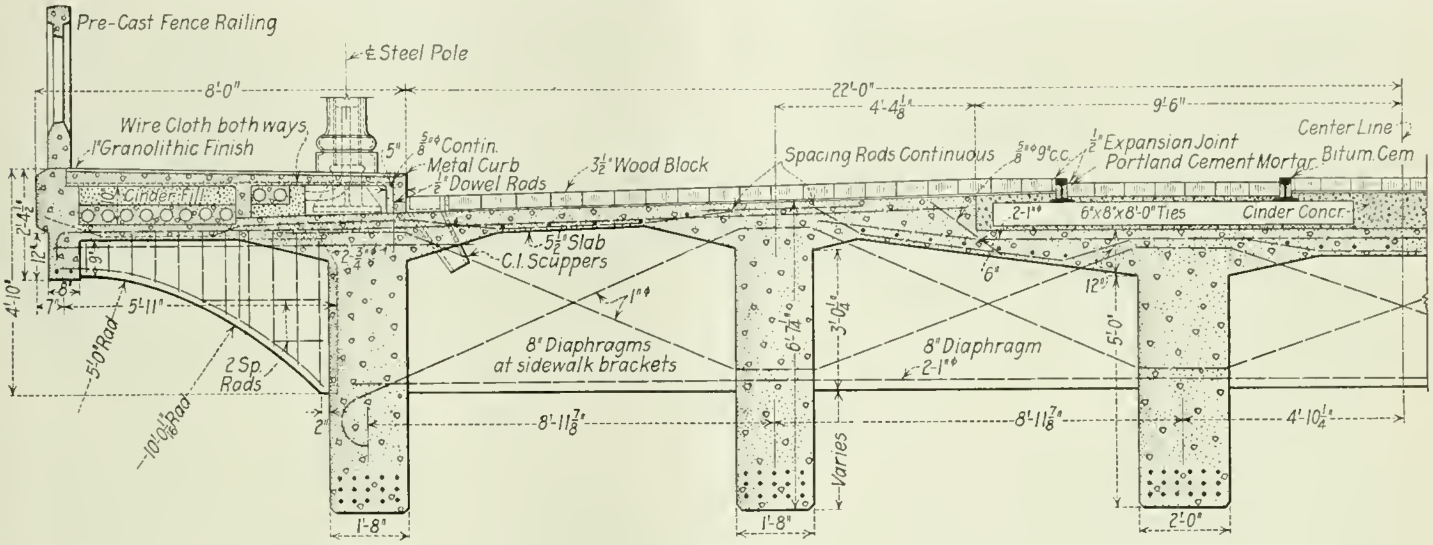


Fig.4

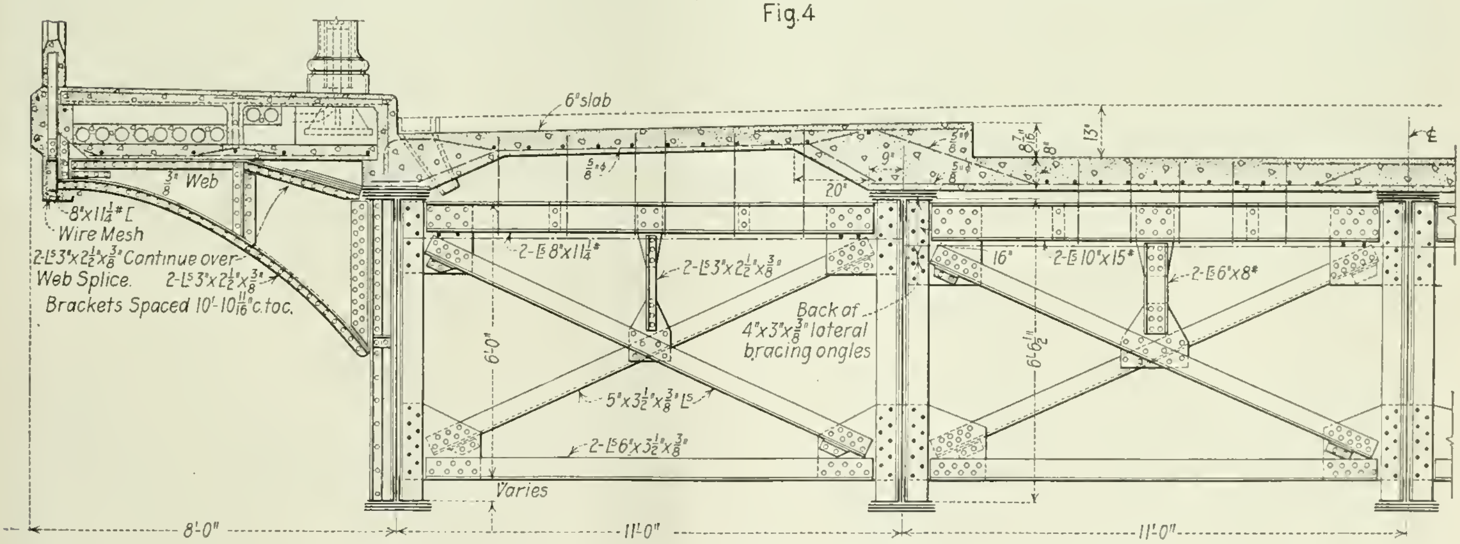


Fig.5

Fig. 4—Half Cross Section of Reinforced Concrete Girder Span of Portland-South Portland Viaduct. Fig. 5—Half Cross Section of Steel Girder Span.

Details of Design.

Figure 1 is a half elevation of a cantilever and suspended concrete span and of an adjacent anchor span; Fig. 2 is a detail of the joint between a concrete cantilever girder and its adjacent suspended girder, and Fig. 3 is a detail of the joint between a steel cantilever girder and its adjacent suspended girder. These drawings clearly show the type of construction and the reinforcement used in the concrete spans, and give details of the triple-seated joints between both the steel and the concrete anchor and cantilever spans. As shown in Fig. 2 the suspended spans are supported on a triple-seated connection, consisting of embedded angles with rocker and bearing plates between them. To avoid interference with the main reinforcing bars a considerable portion of the horizontal flanges of these angles are sheared off.

Figure 4 is a half cross section of a concrete girder span, and Fig. 5 is a half cross section of a steel girder span. These drawings show the principal features of these spans.

The sidewalk brackets of the concrete girder spans and the concrete railing throughout were cast as units in sand molds. The railing posts were cast in place. The brackets were first set in place; the outside girder was then poured, followed by the fascia girder; the conduits were then laid, the sidewalk slab placed in position, and the panels of railway finally set in place between the cast-in-place posts.

The roadway surfacing consists of 3½-in. wood blocks. As shown in Fig. 4 the central 19 ft. of the roadway is occupied by the railway tracks. The ties are embedded in cinder concrete, placed in a trough left in the concrete roadway slab.

The sidehill construction in Section 6 consists essentially of a row of columns at the downhill side of the viaduct, into which frame cross girders, or walls, 12 in. thick. These support a reinforced concrete floor. The sidewalk on the uphill side is constructed directly on a fill or cut, while that on the downhill side is supported on brackets cantilevered from the columns.

Construction Features.

The construction of the piers covered by the portion of the viaduct in tide water presents some interesting features. These piers are founded on wood piles. Upon each group of piles there was placed a concrete platform, built in the form of a scow, 4 ft. deep, with compartments, the side and transverse walls being 12 in. thick. The floor consists of a 6-in. concrete slab on 3-in. tongue-and-groove Southern pine planking. A 6x12-in. Southern pine footing piece runs entirely around the scow, outside of the walls; in it there are steel hook-bolts, spaced 4 ft. apart, by which the platform is attached to its caisson. The caisson walls are built up around the concrete walls of the scow. These caissons consist of 12x12-in. corner posts, 6x12-in. sides, 12x12-in. horizontal inside wallings, and 4-in. planking. Each caisson is attached to the scow by means of eye-bolts, which engage the hook-bolts of the scow.

After being towed to position over a pile group the caisson is allowed to settle, and is then filled with concrete. The pier, which consists of a concrete core faced with ashlar masonry, is then constructed. The caisson is released later from its scow, or platform, by unhooking the bolts, after loosening the turnbuckles with which they were provided. This plan of construction was worked out by J. W. Rollins, of the Holbrook, Cabot & Rollins Corporation, contractors for this part of the work.

Personnel.—The viaduct was designed by J. R. Worcester & Co., consulting engineers, of Boston. The construction work is being done under three general contracts by the Holbrook, Cabot & Rollins Corporation, of Boston, the Phoenix Bridge Co., of Phoenixville, Pa., and T. Stuart & Sons, of Newton, Mass.

A GRAPHICAL SOLUTION OF THE PROBLEM OF STORM FLOW THROUGH A RESERVOIR.

Contributed by Albert S. Fry, Morgan Engineering Company, Memphis, Tenn.

In working out the design of a large reclamation project in northern Mississippi it was necessary to determine the effect of a reservoir upon the flow in a river channel. The particular river in question had its headwaters in a hilly country which is subject to heavy rainfall and rapid runoff. The river flowed from these hills out onto the flat delta lands of the Mississippi River, and at the point of emergence from the hills the river channel had only sufficient capacity to carry about 1 per cent of its extreme flood flow. In planning the reclamation of the delta lands it was contemplated to hold back the hill waters by means of a detention reservoir provided with outlet tunnels and a relief spillway for the most excessive storms. Owing to the fact that the river could carry such a small percentage of the flow from the hills, it was necessary to investigate the flow through the reservoir during the progress of a large number of storms of varying durations and intensities.

The problem of routing these storms through the reservoir was first attempted by the "step" method, but it was found that the means involved a considerable number of mathematical calculations and trials of a more or less routine nature. In order to reduce the computations to a minimum and to facilitate the speed of the work the writer developed a set of "inflow curves" by means of which the effect of storms upon the flow in the river channel could be ascertained graphically.

Preliminary to constructing the "inflow curves" a topographic survey of the reservoir site had been made and the location of the dam determined. The volume of the reservoir had been obtained for each foot in rise of elevation and a capacity curve drawn. A careful study of the factors involved had fixed the size of the dam, the dimensions of the outlet tunnels to permit a safe flow down the river, and the length of spillway. Knowing the size and length of the tunnels and the length and shape of the spillway, the discharge was calculated for various depths of water in the reservoir and a discharge curve drawn.

With this data at hand, the "inflow curves" were constructed. The following relations form the basis for the curves:

Let R = The rate of filling or emptying the reservoir.
I = The rate of inflow into the reservoir for any given period of time.
Q = The discharge through the outlet tunnels.
Q' = The discharge over the spillway.

Then, for all depths of water in the reservoir up to the crest of the spillway,

$$R = I - Q,$$

and for all greater depths—that is, with water passing over the spillway—

$$R = I - (Q + Q').$$

Positive values of R indicate that the reservoir is filling and negative ones that it is emptying.

The first step in making the curves was to divide the interval between the lowest elevation in the reservoir and the highest allowable elevation into increments of height such that no appreciable error was occasioned by using the discharge for the mean elevation of the increment. From the capacity curve the volume between the initial and final elevation of each increment was obtained, this giving the volume which must be filled before the water level in the reservoir reaches the final elevation. The discharge for the mean elevation of each increment was next secured from the discharge curve.

The difference between the inflow for any period and the discharge at any stage in the reservoir will be the rate at which the reservoir is filling or emptying for the period for which the inflow occurs and for the particular stage at which the reservoir is at the time of the given inflow. For convenience, it was first considered that the reservoir was filling at the rate of 1,000 sec. ft., or 3,600,000 cu. ft. per hour. By dividing the increments of volumes between any two successive stages by 3,600,000, the number of hours which would be required to fill the chosen interval if R equals 1,000 sec. ft. was obtained. The number of hours for any rate other than 1,000 sec. ft. could then be secured by inverse proportion to the time required, for R equals 1,000 sec. ft. The values for R equals 1,000 sec. ft. were tabulated, together with other pertinent data, in the form shown in Table I:

TABLE I.

Upstream gage height. Initial.	Final.	Mean.	Storage, bill. cu. ft.	Hours if R = 1,000 sec. ft.	Total discharge, sec. ft.	I = 7,000 sec. ft. R, sec. ft.	Δ T, hours.	Σ Δ T, hours
195	199	197	0.12	33.4	920	6,080	5.5	5.5
199	203	201	0.35	97.3	1,609	5,400	18.0	23.5
203	207	205	0.63	175.0	2,060	4,940	35.5	59.0
207	211	208	1.00	278.0	2,440	4,560	61.0	120.0
211	215	213	1.35	375.0	2,760	4,240	88.4	208.4

If I be assumed constant, then as the stage in the reservoir becomes higher the discharge becomes greater, R becomes less, and the time of filling each succeeding increment of volume is increased. By dividing the number of hours required to fill each increment of volume when R equals 1,000 sec. ft. by the number of thousands of second feet in the varying values of R for each constant, I, a set of values is obtained which gives the number of hours required to fill each particular volume increment. These values are set down in Table I in the column headed ΔT. By summing up these quantities the total number of hours required to fill the reservoir to any given elevation is obtained, the summations being placed in Table I under the head $\Sigma \Delta T$.

The inflow, I, was varied throughout the range which was likely to occur and a different set of values secured for $\Sigma \Delta T$ for each value of I. Using the upstream gage heights as ordinates and the values of the total time as abscissae, a separate curve was platted for each I, the result being a series of so-called "inflow curves."

The procedure described above applies to the case where the reservoir was filling. The process was quite similar for the opposite case of the reservoir emptying.

In this instance it was necessary to begin at the highest elevation of the water surface in the reservoir. R then refers to the rate of emptying instead of filling, but the same values for R equals 1,000 sec. ft. evidently hold good. I was assumed constant, and varied from zero through the different values for which the reservoir is emptying, the values of T being secured as before. Gage heights were again platted as ordinates against values of total time as abscissae. These curves were platted down to the elevation where the rate of inflow just equals the rate of outflow, the curves becoming parallel to the axis of abscissae at these points. For elevations lower than where the inflow and outflow are equal, the reservoir was filling and the filling curves likewise become parallel to the axis of abscissae at the same elevation as the emptying curves.

Having platted the two series of curves for the conditions of reservoir filling and reservoir emptying, the maximum upstream gage height produced by any storm was easily found. From stream gagings and rainfall records the inflow for various storms was known. Using the rate of inflow for the beginning of a storm, the curves were entered at the elevation existing in the reservoir when such rate of inflow occurs. This elevation was ordinarily that at which the storage capacity of the reservoir was considered to begin, but in the case of repeating storms this was not true, because the flood waters of the previous storm had not always emptied when another storm occurred. At whatever elevation the curves were entered, the process of operation consisted in moving parallel to the axis of abscissae along this elevation line until the curve for the given inflow was intersected. Then the motion was upward along the inflow curve for the number of hours during which the given inflow exists. The point arrived at was the final gage height attained for the period and inflow under consideration.

During the next day or period of time some other inflow usually occurred. From the final gage height just found it was necessary to move along the elevation line to the curve for the new inflow and to continue along it for the required number of hours in order to find the final gage reached during this second period of time. By following out this method of procedure the maximum height in the reservoir for a large number of storms was obtained. Where the condition was such as to show that the reservoir was emptying the emptying curves were used in much the same manner as the filling curves.

The mechanical operation of the curves was expedited by the use of a cutout from stiff paper. This consisted of a rectangular-shaped piece of paper from which an inner rectangle had been removed. The short inner edges of the remaining border were graduated with a scale of hours. This device proved very useful in moving from one curve to another and then up the height attained in the given period of time and entirely obviated the necessity of reference to the scale of total hours.

The scale of total hours, then, became of little use in the manipulation of the graph. The chief use of these quantities was in platting and in showing how long it would require to fill the reservoir to a given elevation with a given inflow.

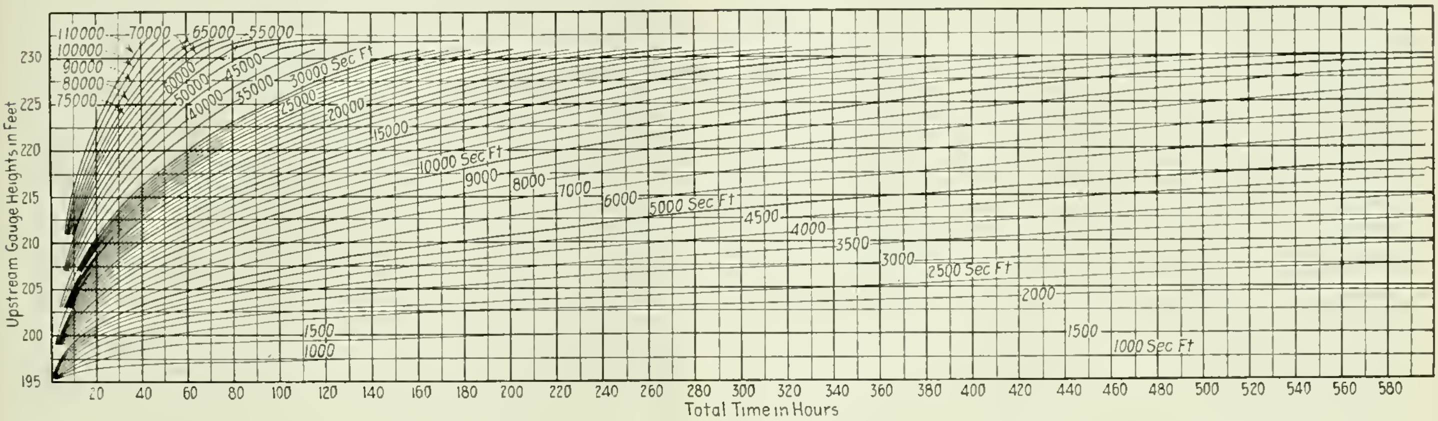


Fig 1

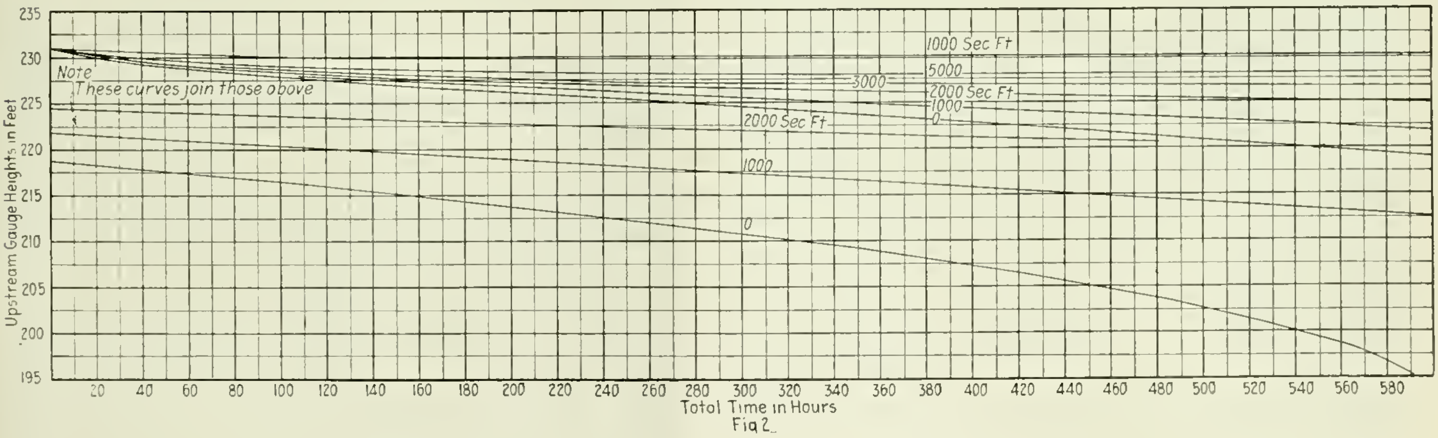


Fig 2

Figs. 1 and 2—Diagrams Illustrating Storm Flow Through Reservoir.

The actual rates of inflow did not, evidently, fall upon one of the platted curves, since these were constructed for 1,000 sec. ft. values. However, the interval between the platted curves was so chosen and sufficient curves platted that no appreciable error was introduced by using the curve for the inflow nearest the actual inflow. It will be noted that the slope for any two adjacent curves is practically the same at any point, so that the use of either curve for an intermediate inflow would give a satisfactory result.

The upstream gage height having been determined for succeeding periods of time, the corresponding river discharge was read from the discharge curve. A comparative graph was then prepared to show the effect of the reservoir on the flow in the river channel during any given storm.

The chief advantage of using these inflow curves is that they may be used to obtain correct results only after the outflow conditions are fixed. A change in the dimensions of the outlet works invalidates the curves for further service in securing exact results, inasmuch as any such change necessarily produces new discharge conditions. In order to obtain accurate results an entire new set of curves must be constructed for the changed conditions.

However, where it is possible, by preliminary calculations or otherwise, to fix the physical dimensions of the structures involved, the usual lengthy computations to find the highest elevations reached for a large number of storms are dispensed with. No appreciable error is introduced by the use of the graphs, and it is believed that the results obtained are within the limits of accuracy justified by the ordinary knowledge of rainfall and run-off conditions. The difference between the mathematically calculated gage height and that read from the graph was found by the writer to be only one or two-tenths of a foot in several cases for which both methods were employed.

The speed of the work was also aided by the use of the curves. The probabilities for making mistakes were doubtless less when the graph was used than when it was necessary to work out a mass of mathematical computations. The psychology of the process involved in using a graph reduces a series of tedious mathematical calculations to the far more pleasing task of operating the mechanism of a group of curves.

In dealing with a particular problem the inflow curves were developed in order to know the effect of the reservoir upon the stream flow. But they also served another purpose in that they gave a basis of comparison for a large number of storms by showing the maximum height in the reservoir produced by each particular storm. Since this comparison was obtained for the special case dealt with, it has occurred to the writer that a standard set of similar curves might be used as a basis for the comparison of the relative magnitudes of any number of different storms.

From an examination of the existing records of rainfall or stream flow it is not easy to decide whether a heavy storm of short duration will prove more disastrous than one of less daily or hourly intensity but spread out over a greater period of time, or that either of these may be more dangerous than what would ordinarily be a harmless storm coming soon after a previous storm. If these several storms should be routed through a standard reservoir the respective depths produced would form a comparison of their relative severities. If it is desired to investigate the character of several grades of sand, we may compare the results obtained from tests with them with the results secured from the standard Ottowa sand. In like manner, it would appear that the character of different storms might be compared by observing their effect on a reservoir whose dimensions and outflow conditions conformed to some agreed upon standards.

FOUR YEARS' EXPERIENCE IN MOSQUITO EXTERMINATION AT PHILADELPHIA.*

By William H. Connell, Chief, Bureau of Highways, Philadelphia.

The mosquito extermination campaign in Philadelphia started in July, 1912, with an appropriation of $5,000 for experimental and actual work. The poor drainage system over 8,000 acres of lowland in the southern section of the city caused through obstructed ditches, which had not been properly maintained for several years previous to that time, had practically converted this area into swamp land where millions of mosquitoes bred annually. During the past year 30 different varieties of mosquitoes were identified and large numbers of malaria-bearing mosquitoes were found in all sections of the city.

Preparatory to starting the actual work of mosquito extermination in 1913 the early part of the year was devoted to an educational campaign in which many lectures were given and over 100,000 pamphlets bearing on the life history of mosquitoes and practical methods of extermination were distributed throughout the city to solicit the interest of the public. The appropriation of $5,000, however, did not permit of a decisive fight against the insects in the city limits simultaneously, and the work was confined principally to sections where they bred habitually and to relieve local complaints. During this year the salt-marsh species, a larger and more active mosquito than the house-breeding variety, made its appearance in the lower part of the city in large numbers and much time and attention were given to extermination work against this particular pest in its original breeding places.

The force of men varied from 2 to 8 during the season of 1914, and, while the appropriation was curtailed, a great deal of very satisfactory work was accomplished in oiling pools throughout the summer and latterly in oiling sewer inlets, which was tried out for the first time in the fall and continued until the middle of December. As a result, mosquitoes which ordinarily hibernate in sewer inlets over the winter were practically prevented from breeding and no complaints of the mosquito nuisance were received until four weeks after the first heavy rains in May, 1914.

The work of mosquito extermination in 1915 began on June 1, with an appropriation of $2,500, and extended to November 15. Probably no season since 1912 proved so very favorable for breeding purposes, as rain occurred at short intervals and formed thousands of pools. Breeding places on roofs and in tin cans on dumps and private property added to the multitude of complaints of mosquito annoyances. At one period of the summer the situation became so bad in many built-up sections of the city, bordering on large unimproved areas where weeds were permitted to grow to a height of 6 or 7 ft., that the city was forced to put an additional force of 200 men at work cutting down areas of weeds infested by mosquitoes. Table I gives data on the work in 1915.

The actual appropriations for mosquito extermination during the past four years amount to $13,900, and this amount, of course, is not sufficient to handle such a proposition, so important to the health and comfort of a community of the size of this city. With the limited appropriations, however, much progress has been made, and since 1912 over 65 miles of ditches have been reconstructed, which will permit of the proper drainage of an immense area which has heretofore afforded ideal breeding places for these pests. Approximately 12,000,000 sq. ft. of pools have been oiled and sprayed, 27,000 sewer inlets oil treated and 300,000 sq. yd. of weeds cut down in the effort to improve living conditions during the mosquito season. With a proper amount of money an entirely different plan than heretofore used for mosquito work could be put into effect, which it is confidently predicted would free the city from the mosquito nuisance.

TABLE 1.—WORK DONE BY PHILADELPHIA CITY FORCES ON MOSQUITO EXTERMINATION, 1915.

	No. of jobs.	Cost of labor.	Cost of material.	Total cost.
Oiling pools	2,600	$ 280.00	$ 49.50	$ 329.50
Oiling sewer inlets	22,500	1,725.00	142.00	1,867.00
Filling in depressions, ditching, etc.	250	1,145.00	150.00	1,304.00
Totals	25,350	$3,159.00	$341.50	$3,500.50

THE TREATMENT OF COLLIERY AND OTHER TRADE WASTES IN THE EMSCHER DISTRICT.

Translated and abstracted by Kenneth Allen, Engineer of Sewage Disposal, Bureau of Public Improvements, Board of Estimate and Apportionment, New York City.

The valley of the Emscher River in Germany, as is well known, is noted for its extensive coal mines, its iron and steel works and its various manufacturing industries, so that the question of the treatment of trade wastes is, in some localities, of permanent importance.

Dr. Bach, late chemist to the Emscher Board,* wrote a monograph† on this subject before the war broke out which is of interest to engineers who have to deal with sewage disposal problems.

In the Emscher District collieries and iron works produce by far the greater volume of the trade wastes, as is indicated in the following table:

---

*From advance copy of 1915 annual report.

*Dr. Bach has since been killed in battle.

†"Das gewerbliche Abwasser im Emschergebiet."

	Cu. ft. sec.	Per cent.
Iron Industries	38,041	66.11
Mines	14,568	25.32
Breweries	1,103	1.92
Distilleries	149	0.26
Slaughter houses	360	0.63
Miscellaneous	2,805	5.76
Total	57,026	100.00

The salinity of the stream, which is caused principally by mine drainage, is shown to be a matter of considerable importance. Where this exceeds 3 grams of NaCl per litre the water is pronounced unfit for cattle to drink, and where it exceeds 0.5 to 1.0 gram per litre the water is rendered unsuitable for irrigtion. From analysis of the waters of the Emscher River and many of its tributaries it would appear that these waters are in general unfit for most industrial purposes and in the main for either watering cattle or irrigation.

The water from coal washing contains a large amount of slack and this, when mixed with domestic sewage, renders it difficult to treat in Emscher tanks. This is partly because the finer particles settle out very slowly, weeks or even months being required to effect clarification, resulting in preventing the separation of much of the organic matter, and partly because the individual particles do not disintegrate or decompose and are therefore liable to cause a clogging of the sludge pipes. Such wastes should therefore be treated by themselves before admixture to sewage which is to be settled. For this purpose the "Imhoff-Lagemann" process is recommended, where the slack is first allowed to separate out by sedimentation in special tanks, the supernatant water being then drawn off and the deposited material air-dried for from 3 to 10 days and then removed.

Although over 90 per cent of the trade wastes of the Emscher District come from collieries or iron works, those from breweries, distilleries and slaughter houses are more generally found in the average town and these subjects are treated with much detail in Dr. Bach's paper. The conclusions arrived at are briefly as follows:

Noting that the total volume of the trade wastes in the district is about eight times that of the domestic sewage it follows that treatment of the former requires most careful consideration.

The plan of discharging trade wastes into a stream depends not only upon their volume, but upon their polluting character, and putrescible domestic sewage must be carried off and disposed of promptly and warrants greater expense for an outfall than is necessary in case of trade wastes which, as a rule, are less putrescible.

Domestic sewage is of such a foul character that it should be treated before discharge to a stream, such treatment being usually mechanical, but in some cases biological. Most trade wastes, on the other hand, are not sufficiently impure to require any treatment at all, an exception to this being in the case of water from coal washings which requires special provision for the removal of the slack.

It is, of course, not always practicable to keep trade wastes separate from domestic sewage, leaving the latter only to be treated. If the two are brought to the treatment plant in a single conduit it results in a corresponding increase in the size of the works.

In general it may be said that the systematic drainage of the Emscher District, so far as trade wastes are concerned, is carried out by the removal of practically their entire volume with such treatment as is necessary, while in the case of domestic sewage, it is absolutely necessary to provide clarification plants. The increasing salinity of the waters of the Emscher River and its tributaries due to mine drainage prevents their use for agricultural or domestic purposes and as for fish culture, that is out of the question. The Emscher Board does not attempt to reclaim the streams receiving sewage for such purposes, as the expense of bringing this about would be out of all proportion to the ends sought.

Where treatment of trade wastes is desirable this need not, however, be always done apart from the domestic sewage. For practical reasons it is often better and less expensive to mix the two together. In many cases a reasonable amount of preliminary cleaning of such wastes at their source is recommended in order that the two may be subsequently treated together. Coal mine wastes, for instance, should be first freed from slack on account of its objectionable effect in tank treatment.

To sum up, the attitude of the Emscher Board toward trade wastes is as follows: They may be either discharged directly to the stream or treated with the domestic sewage in plants provided for the latter. Special plants for their treatment are avoided as much as possible. Only such wastes as contain material objectionable in the operation of the plants of the district, or as would render the bed of the stream to which they are discharged foul, should be treated at their source.

PAINTING AND MAINTAINING STEEL HIGHWAY BRIDGES.*

By George Hogarth, Chief Engineer of Highways for Ontario, Canada.

Painting.—The condition of the surface of the steel before it is painted has a very important relation to the life of the paint applied to it. To prepare properly the steel surface for painting all rust should be removed by steel scrapers, chisels and wire brushes. In carrying out the operation of cleaning considerable care and muscular effort on the part of the workmen is necessary, and unless a good inspector is present the work is likely to be slighted and inferior results obtained. Great emphasis should be given to the fact that all rust, dirt and grease should be removed before the shop coat of paint is applied, since upon this coat depends the life of the entire painted surface. To develop and encourage the custom of keeping steel highway bridges properly painted is a duty which those in authority should assume and establish a definite course of action.

On large bridges, which are carefully and systematically looked after, painters are employed during the favorable seasons of each year and are kept steadily at work scraping and painting the various parts of the structures. The railways of this country have millions of dollars invested in steel bridges, and they insist on having experienced men paint all of their steel structures. A bridge which is painted every four years after being built will only require five complete paintings to last 25 years, and at the end of that time it should be in good condition. Yet the general experience is that bridges built about 20 years ago are today in a very doubtful condition, due to rusting. The cost of a few paintings is only a fraction of the first cost of any steel bridge, and systematic painting is true economy.

Careful attention to the painting of steel bridges should be given from the day the structure is first completed. Semi-annual inspections in the early spring and fall should be made of all structures, and wherever small failures of the film of paint are discovered the painter should at once be ordered out to scrape carefully and repaint the exposed parts. Every four or five years the structure will require complete repainting. Immediately before the paint is applied the steelwork must be carefully and systematically cleaned of all dirt, loose paint and rust. A complete supply of steel brushes, scrapers and chisels should be provided for the men and frequent visits to the work should be made to see that these tools are used. The structure should be painted in sections as fast as the cleaning progresses, and three coats of paint applied. In all cases ample time should be allowed between coats to enable the proper drying of the film. Weather conditions during painting have considerable influence on the life of paint, and it is advisable that the complete repainting of bridges be undertaken only during the warm, dry months of the year. Care should be taken to see that the steel is dry before commencing work in the morning and probably the best plan would be to have the men attend to other work till, say, 8:30 a. m. Actual experiments have proved that painting on wet or damp surfaces shortens the life of the paint.

For the information of the official in charge of the work, the date of painting should be stenciled on some convenient part of the structure in order to facilitate the recording of the action of the paint during its life.

---

*Extracts from paper before recent conference held by Ontario Department of Public Highways at Ontario, Canada.

The selection of a paint for steel bridges is a problem that possibly all have been called upon to solve at one time or another. To be satisfactory a paint must fulfil many exacting requirements. While these requirements are numerous and are apparently difficult to fulfill it is possible today to purchase in any locality the necessary ingredients which, when combined, will produce a reliable paint for steel structures. There are also on the market today a number of ready-mixed paints which the manufacturers recommend as a protection for structural steel. For many years a red lead and linseed oil paint has been extensively used for priming and field coats for a large number of bridges. At times there has been a tendency to abandon such coverings of proven merit in favor of more modern proprietary paints, but usually, after unfavorable experience with the newer ideas, a return is made to the red lead. Where objection is made to the bright color of red lead in the finishing coat it is suggested that the third coat be darkened by the addition of lampblack. If pure lampblack is used in the final coat the life of the paint will not be shortened.

General Maintenance.—A steel highway bridge requires the proper careful attention due to that class of structure. Changes are constantly occurring in various parts of its members and thorough semi-annual inspections are imperative if the structure is to continue in a safe condition for public travel.

The inspection in the spring should be undertaken with a view to ascertaining the general condition of the structure and also to lay out and decide on the manner of carrying out whatever work is to be done at the bridge during the following summer. The fall inspection should be made with a view to estimating the cost of whatever repairs may be required during the following summer.

Many instances could be cited where an inspection of a bridge has revealed a serious condition of affairs due to broken sections which, if unattended to, might result in serious damage or complete collapse of the structure. Until recently many of the structures built were pin-connected and were provided with tension members composed of square rods with a welded eye at each end. Indifferent workmanship in forming the weld creates a weak spot which, after a few years of service, becomes apparent when the weld breaks open. If there are two bars in the member there is still sufficient strength available to carry the structure pending immediate repairs, but in no case should unnecessary chances be taken and if the inspector is in any doubt as to the ability of the structure to stand up, the best course to pursue is to close the bridge till repairs are completed. The manner in which steel sometimes breaks is very difficult to account for, and frequent inspection is the only way in which the safety of the bridge can be certified to. Steel is the same as any other commercial product, and carelessness in manufacture is reflected in the action of the finished article.

The semi-annual inspections should include every portion of the bridge—the handrail, the approaches and the river channel. Attention to the condition of the approach handrails to discover loose or decayed sections is advisable.

The trusses should be inspected to see if they are still in line, and the chords should be carefully examined to discover any twists or deflection and to ascertain if the camber is true and uniform. All tension members should have quality of stress in each, tested by springing them with a sharp blow of the hand, and particular attention to the joints of such members should be given. The posts and lateral struts should be straight and free from twists. All lateral bracing is to be examined to see that it is straight and tight, and is taking such stresses as it should. In some bridges lateral members are adjustable, and where such is the case all nuts should be tightened to a full bearing. After the nut is tightened it should be secured by burring the thread of the bolt in two or three places with a center punch or chisel.

In pin-connected bridges, any pins which indicate movement should be noted, and the nuts should be examined for tightness. Any members having closed sections which catch and retain water should have proper drain holes drilled. Look for loose rods, hangers and braces and other defects of a like character which require adjusting in order that each of the different parts may have proper bearings and may carry its proportion of the load. Observe the structure during the passage of a heavy load, and note any undue vibration or deflection which, if followed up, may lead to the discovery of a defective part. Carefully examine the connections between stringers and floorbeams and between floorbeam and trusses. See that rivets are tight and that connection angles are sound. The expansion and fixed end shoes and anchor bolts also call for careful attention to discover any movement of piers or abutments. Rollers of expansion bearings require careful cleaning to preserve them and to allow their proper operation. It is advisable to sweep and clean the bridge seats as often as necessary, since a considerable amount of mud usually is washed down from the roadway and, gathering around the steel, tends to induce rapid rusting.

The practical test of observing the bridge during the passage of a heavy load may result in the discovery that the various parts appear to be loose and that the entire structure appears to be working or moving. If there are a number of adjustable members in the trusses and lower laterals it is probable that the tightening of such, with no load on the structure, will correct any apparent looseness; while if the bridge is fully riveted it is desirable that close attention be given the various joints to see that the rivets are still tight. If a number of loose rivets are found, it is advisable to cut them out and again rivet the connection.

Careful attention should be given to the drainage of the floor. If the bridge has a concrete floor the drains should extend through and beyond the concrete for a distance of 1 or 2 in. and should be so placed that the drip does not strike any part of the steelwork. Drains less than 3 in. in diameter should not be used and they should be cleaned out at frequent intervals. Where drains have been omitted from a floor it is desirable that holes be drilled along the curb at the low points and that suitable drains be concreted into place. The proper drainage of the floor prevents the water running off each end of the bridge, where it either damages the approach roadway or carries dirt down the ballast wall to litter up the bridge seats. The bridge seats should also be examined, preferably after a rainstorm, to see if they are sloped so as to drain the water and not allow it to gather where it might assist corrosion.

Should any member of the structure be accidentally crippled while in service the best method of repair requires careful consideration, but, as a general principle, it is advisable to remove entirely the damaged part and renew it. Sections which have been subjected to heavy punishment are not reliable, and a new member completes the repair in the most satisfactory manner. A slight fire on part of the structure may reach and affect some of the members and yet not cause the collapse of the bridge. The effect of such heat treatment on the strength of the steel is so uncertain that it is very desirable to remove the members which have been heated. Wooden floors of various descriptions are in some cases bad fire hazards and may imperil the entire structure. The danger to structures from fire due to nearby material or buildings is evidently not as great outside of the cities, yet it is desirable that such points be kept in mind during inspections. Wood lying around on the ground under the structure, or driftwood in the river, may be the cause of trouble, if allowed to accumulate. A few dollars paid out in clearing away and carefully burning such material is usually well spent. The river above and below the site of the bridge should be inspected to see that the channel is not changing, or that the banks are not being carried away in such a manner as sooner or later to interfere with the security of the approach roadway or the abutments. Such an occurrence demands prompt attention and the supplying of an ample quantity of rip-rap or the excavating of a new river bed to afford a proper escape for the water.

During repairs to structures or flooring, where traffic must be maintained on busy roads, adequate precautions to prevent accidents to pedestrians and vehicles should be taken. Proper fencing is imperative, and lights should be provided at night.

In many cases the carrying capacity of a steel bridge of slender appearance is questioned merely because of its general appearance. The weak part of a bridge usually is the floor, and if that is sound a little care is often all that is required to pass heavy loads.

The maintenance of steel highway bridges thus resolves itself into a large number of small but nevertheless very important details, which, with proper attention, will greatly lengthen the life of the structures. Our highways will receive more careful attention in the future, and it is imperative that the steel bridges along them be efficiently inspected and that their maintenance be kept up to the same degree of excellence as the roadway proper.

THE SECOND CONFERENCE OF THE COMMITTEE ON ENGINEERING CO-OPERATION, CHICAGO, APRIL 13-14, 1916.

The Second Conference of the Committee on Engineering Co-operation, held at the rooms of the Western Society of Engineers, Chicago, April 13-14, 1916, was attended by over 40 representatives of national, state and local engineering societies throughout the country, and by a large number of engineers interested in the movement. The scheduled list of addresses and papers (each limited to 15 minutes) follows:

Co-operation Among Engineering Organizations; Is It Desirable?, by Paul Hansen, president, Illinois Society of Engineers. Practicability of Co-operation, by John Howe Peyton, president, Nashville section of Engineers' Association of the South. Co-operation Among Local Societies, by Willard Beahan, Cleveland branch American Society of Civil Engineers. The Philadelphia Plan, by Lewis R. Ferguson. The Chicago Engineers' Club, by B. F. Affleck, president of that club. Co-operative Efforts in Chicago, by H. S. Nichols, secretary of the Chicago section of the A. I. M. E. Ideals and Accomplishments of Various Types of Engineering Organizations, by H. H. Esselstyn, past president Detroit Engineering Society. The National Society and Its Members, by Peter Junkersfeld, American Institute Electrical Engineers. Engineering Education, by J. F. Hayford, dean of Northwestern University. Publicity for Engineers, by C. E. Drayer, secretary Cleveland Engineering Society. Employment, by Arthur Kneisel, American Association of Engineers. The State Engineering Society, by Clyde T. Morris, president Ohio Engineering Society. Co-operation in Minnesota, by Geo. H. Herrold, president, Civil Engineers' Society of St. Paul. Aims and Accomplishments of the American Society of Heating and Ventilating, by J. F. Hale. Co-operative Efforts Toward Engineering Experiment Stations, by Dean A. A. Potter, Land Grant College Engineering Association. Altruism, by Geo. W. Rathjens, St. Paul. Co-operation in Wisconsin, by Fred G. Simmons, Wisconsin Engineering Society. Duties of the Engineering Society in Legislative Matters, by H. J. Burt, Illinois Society of Structural Engineers. The Engineer and Contractor, by DeWitt Moore, American Society of Engineering Contractors. The Public and the Engineering Profession, by A. J. Himes.

The thought most commonly expressed at the conference was that co-operation among existing engineering societies is highly desirable, but that the formation of a new society is undesirable. The spirit of the conference is well expressed by the following quotation from a letter to the conference by Isham Randolph:

> Let us have a central organization—call it what you will—which has no authority to command, but which has ears to hear and the voice to be heard, and let those ears be open to every plea or promise of common good, and let that voice go out to all affiliated bodies carrying this plea or this promise for the common good, and let us come together at least once a year and feel that "touch of nature which makes the whole world kin," and growing out of that kinship let us consider and do those helpful things which will bless our comrades and overflow with helpfulness to our country and our kind.

The constructive work of the conference and the future work laid out are indicated by the resolutions unanimously adopted, which are:

WHEREAS, the rapid increase in engineering activity of recent years has given rise to many problems vitally affecting the practice of engineering, and

WHEREAS, existing agencies, through lack of proper correlation, appear inadequate for the solution of these problems, and in order that the resources of the profession may be made available for the most useful service to the nation, state and municipality, and that the practice of engineering may be rendered more efficient and less burdensome in those places where its development has been most difficult, and

WHEREAS, it is the sense of the Second Conference on Engineering Co-operation representing societies, national, state and local, and comprising various branches of engineering, that these ends may be attained through a closer association and co-operation of engineering societies, be it

RESOLVED: That there is hereby established a sub-committee, with Mr. F. H. Newell as chairman and four other members to be selected by him, with instructions to prepare a plan for forwarding co-operation among engineering societies upon matters of general interest to the engineering profession, such plan to be presented for formal consideration at a third conference on engineering co-operation to be called by the sub-committee at such time and place as may seem to it desirable. Be it further

RESOLVED: That the several organizations represented at this conference should be permitted to assist in defraying the expenses of the committee on engineering co-operation and that the sub-committee should be requested to present to each of the societies represented an estimate of probable expenditures, including clerical service, together with recommendations for equitable prorating. Be it further

RESOLVED: That this conference express its high sense of appreciation for the courtesies and hospitality extended by the Western Society of Engineers, Sub-Division 63 of the Chicago Association of Commerce, and the Chicago Engineers' Club, and hearty thanks therefor are hereby expressed.

The success of the second conference was largely due to the altruistic and untiring work of F. H. Newell, chairman, and C. E. Drayer, secretary, of the Committee on Engineering Co-operation.

DESIGNING COMPRESSION MEMBERS FOR SMALL STRESSES.

By Albert Smith, Purdue University, La Fayette, Ind.

All standard specifications contain a clause limiting the value of the free length divided by the radius of gyration, the limit of this fraction varying in different types of structures and in different members. For example, a value of l/r of 100 is prescribed for main members of bridges, a value of 120 for mill buildings, and 120 or 150 for wind bracing. The variation in limit is proper because of the difference in the accidental forces which may act upon the members in the different structures or parts of structures, and because of the different factors of safety desired.

The considerations which underlie this specification are practical, not theoretical. For the formula $16{,}000—70\,l/r$ the permissible fiber stress becomes zero for $l/r = 228.6$, and for all values between 100 and 228.6 the factor of safety is higher, apparently, than for lower values of l/r. The theoretical and experimental ultimate strengths, if divided by the factor of safety will give higher permissible fiber stresses within these limits of l/r than will the straight line formula. But for shop inaccuracies and accidental shocks we might apply the straight line formula without any lower limits of l/r.

It is therefore desirable that we should be bound only by the intent of this specification, and should not be put to needless expense in observing its letter.

Experienced designers of light structures use many sections which apparently do not meet this specification but which are nevertheless quite safe. Inexperienced designers are likely to go astray, and a rational method of examining such members should be of interest.

An impossible case will give the clearest illustration: A compressive stress of 1,000 lb. is to be carried over a length of 120 in. A pipe with thin walls, having a radius

---

*Extracts from paper before recent meeting of Indiana Engineering Society.

of gyration of 1 in. would fulfill the specification. Suppose the proper pipe is not to be had, but that the fabricator has in his stock a solid round bar of the same external diameter. Its radius of gyration is much less, however, and, if a solid bar is to be used, apparently one much larger than the pipe will be necessary. Of course this is not reasonable, and one is justified in regarding the solid bar as a pipe and in disregarding the solid interior cylinder.

As a rule governing such cases the writer proposes that any portion of the cross section of a strut may be neglected in computing the radius of gyration provided that portion also be neglected in computing the safe load.

To show the application of such a rule let us consider the following case: A load of 25,000 lb. is to be carried in a length of 120 in., and 8-in. I-beams are the most convenient to use. From the handbook the least radius of gyration is found to be 0.84, and l/r is therefore 143. If we neglect the 6x¼-in. web we have an area of 3.71 sq. in., instead of the actual total area of 5.33 sq. in., and the new radius of gyration is 1.01 in. instead of 0.84. Under this assumption l/r would be 119, the allowable unit stress 7,670 lb., and the actual unit stress 6,740 lb.

Again, suppose the load to be carried is only 10,000 lb. If we assume l/r = 120, for which value the allowable unit stress is 7,600 lb., the required area will be 1.31 sq. in. Disregarding all the section of the 8-in. I-beam except areas of 0.33 sq. in. at each flange edge we have a radius of gyration of 1.48 in., a permissible unit stress of 7,600 lb., and an allowable length of 178 in.

Using this method of computation it is possible to make very effective use of tees in roof trusses, and even with double angles we can justify much smaller sections than otherwise will be required.

There are many long tension members in roof trusses which are subjected to reversals of stress. If designed according to the l/r restriction, using the actual value of r, the sections either will be unnecessarily large or much expense will be incurred for intermediate bracing.

There are many things which do not appear on the stress sheet for which the designer should make allowance. The writer does not regard it safe to consider that the area neglected in the method given above will provide for eccentricity, shock, and rusting. The load bearing area should be increased to provide for these items.

[The editors will be glad to receive discussion of the rule here proposed.]

A NEW DUTY RECORD FOR STEAM-TURBINE-DRIVEN CENTRIFUGAL PUMPS ESTABLISHED AT MONTREAL.

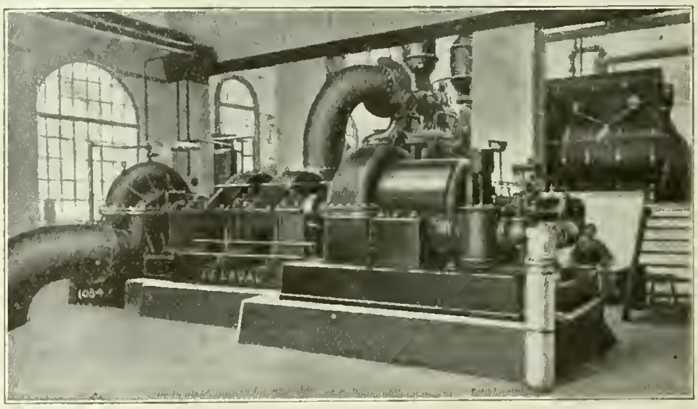
(Contributed.)

Previous Records.—A little over two years ago, the first large steam-turbine-driven centrifugal pump for water works service was installed at the Ross Pumping Station, Pittsburgh. This unit, consisting of a De Laval multi-stage turbine running at 3,600 r. p. m. driving a single-stage centrifugal pump at 350 r. p. m. through a double-helical speed-reducing gear, has a capacity of 100,000,000 gal. per day against a total head of 56 ft., including 18 ft. suction lift. It was guaranteed to give a duty of 115,000,000 ft. lb. per 1,000 lb. of dry steam at 150 lb. pressure gage, including all steam and power used by auxiliaries. In a 10-hour acceptance test a duty of 117,700,000 ft.-lb. per 1,000 lb. of steam of quality 0.977 was shown, equivalent, after correcting for moisture, to 120,500,000 ft.-lb. per 1,000 lb. of dry steam. The total water horsepower developed was 1,056.9 and the steam consumed per water horsepower was 16.4. This result was obtained when the turbine was exhausting to the comparatively low vacuum of 28.38 in. of mercury, compared with a 30-in. barometer.

Subsequently, geared steam-turbine-driven centrifugal pumps of the same type and make were installed in Philadelphia, Toronto, San Antonio, Cleveland, Omaha, Lynn and other cities. A 30,000,000 gal. per hour De Laval unit at the Kirtland Pumping Station of the City of Cleveland, which was started on Dec. 30, 1914, showed a duty of 128,400,000 ft.-lb. per 7,000,000 B.t.u., or 152,020,000 ft.-lb. per 1,000 lb. of steam, at 153.28 lb. per square inch gage and 102.6° F. superheat, when exhausting to a vacuum of 28.25 in. of mercury referred to a 30-in. barometer. During the test the unit delivered at the rate of 30.3 million gallons per day against a total head of 236.3 ft., equivalent to 1,257 water horsepower. The Kirtland unit, which consists of a geared turbine driving two 24-in. centrifugal pumps operating in series, occupies a space of approximately 9 ft. by 35 ft., and weighs only 57 tons.

New Record.—The latest record of duty for steam-turbine-driven centrifugal pumps has again been established by a De Laval unit installed in the Low Level Pumping Station of the City of Montreal. This unit has a capacity of 30,000,000 Imp. gal. per 24 hours against 210 ft. head, and on test has developed the equivalent of 168,000,000 ft.-lb. per 1,000 lb. of steam at 140 lb. gage pressure and 100° F. superheat, excluding friction head loss through condenser and piping. A view of the installation is shown herewith.

The pumping equipment of the Montreal Low Level Pumping Station illustrates the progressive development of water works pumping units. The original installation, made in 1857, consisted of a water-turbine-driven pump. In 1868, a steam-driven auxiliary was added, since which the plant has grown steadily, so that it now contains eight pumping units of a total capacity of 108,000,000 Imp. gal. per 24 hours. The earlier units were of the reciprocating type, but subsequently a number of centrifugal pumps driven by high speed triple-expansion engines were installed, and when in 1914 it again became necessary to increase the capacity of the plant, specifications were issued for two engine-driven pumping units, each to be of 12,000,000 Imp. gal. per day capacity. Bids were received at prices ranging from approximately $22,000 per pump to $27,000 each, the duties offered being around 100,000,000 ft.-lb. per 1,000 lb. of steam.



View of De Laval Geared Steam-Turbine-Driven Centrifugal Pumping Unit at the Low Level Pumping Station of the Montreal Water Works.

However, the results obtained from the turbine-driven centrifugal pumping units in other cities having meanwhile become known, these specifications were withdrawn, and after an extensive investigation of geared steam-turbine-driven centrifugal pumps installed in different places, conducted by Mr. T. W. Lesage, Engineer Superintendent of Water Works for the City of Montreal, new specifications were issued, calling for a single turbine-driven pump of 24,000,000 gal. capacity. Upon opening the bids based on the new specifications, it was found that one bidder had quoted a price of $39,000, while another had bid $47,775 but had offered a duty 23,000,000 higher. As the capitalized value of the increase in duty far exceeded the difference in price, the contract was given to the higher bidder, the E. Laurie Co. of Montreal, representatives of the De Laval Steam Turbine Co., under exacting specifications, from which the following data are taken:

The capacity was specified as 24,000,000 Imp. gal. per 24 hours, but this was subsequently changed, at the suggestion of the bidder, to 30,000,000 Imp. gal. per 24 hours, as the latter capacity could be secured without material increase in the size or cost of the turbine. The steam pressure was specified as 140 lb. per square inch gage with 100° F. superheat. The head pumped against was to be 85 lb. per square inch, plus 5 to 8 ft. suction lift. The bidder was required to state the main dimensions of his apparatus, which, for the De Laval apparatus, were as follows:

Brake HP. of turbine	1,600
Number of stages	14
Speed of turbine, r.p.m.	3,600
Ratio of gear	6 to 1
Diameter of suction and discharge openings of pump, both, in	30
Speed of pump, r.p.m.	600
Efficiency of pump, not less than	80%
Weight of complete unit, including pump, turbine and gears, lb.	80,000
Floor space required, approximately, sq. ft.	247

The vacuum was not specified, but the bidder was required to supply the condenser. That offered by the De Laval Steam Turbine Co. was of the so-called "water works" type, in which the water passes around the tubes and the steam through the tubes. It was to contain 3,000 sq. ft. of surface and was to be served by a rotative dry vacuum pump. The condenser was estimated to weigh 36,000 lb. and the pump 7,300 lb., and the two to occupy a floor space of a little more than 100 sq. ft.

The specifications required that the duty gauranteed should include all losses, including pipe friction, velocity head and steam used by auxiliaries, and it was further stipulated that in determining the duty, the pumping unit should be credited with the vertical distance from the water in the suction well to the center of the pump shaft, while the discharge pressure would be measured at the point of connection with the city main, corrected to the elevation of the center of the pump shaft, the pumping unit thus being charged with the friction through the piping, condenser shell, check and gate valves, etc. It was further required that in calculating the duty test, all steam consumed by auxiliaries should be charged to the main unit, the latter, however, to be credited with heat returned to the boilers by feed water heaters.

It was required that the unit should be tested to its full capacity at the builder's shops before shipment, and after installation at Montreal should be run continuously for 15 days of 24 hours each without shutting down, at the conclusion of which endurance test, a duty test of 8 hours continuous running was to be made. In event of failure to develop the duty guaranteed, a deduction of $2000 was to be made for each million foot pounds by which duty should fall short of the stipulated guarantee.

The following figures summarize the results of the final duty test, which was carried out on Oct. 15, 1915:

Average water delivered per hour, imperial gal.	1,308,808
Corresponding rate per 24 hr., imperial gal.	31,411,292
Average pressure at gage on discharge pipe, ft. head	197,274
Average suction lift from water level to center line of pump, ft.	8.6
Total average corrected head, ft.	205.874
Average water HP.	1,360.85
Steam consumption, lb. per hr., corrected for heat returned in feed water	17,344
Average absolute steam pressure in lb. per sq. in.	159.7
Average actual steam temperature at engine throttle, deg. F.	426
Average superheat at turbine, deg. F.	63
Steam consumption per hr. corrected to contract conditions	16,638
Steam per water HP., lb.—actual	12.7
Duty per 1,000 ft. lb. of steam supplied, in million ft. lb.—actual	155.356
Duty per 1,000 lb. of steam corrected to specified superheat and pressure, in million ft. lb.	162.0

In calculating the above duties, the main unit was credited with an amount of steam equivalent to the heat returned to the boilers in the feed water. Part of this heat was obtained from a primary heater in the main exhaust connection and the remainder from an open heater which received the exhaust steam available.

As previously stated, it was required that the delivery head to be used in calculating the foot pounds delivered should be measured as the pressure at the City force main, corrected to center of pump shaft, plus the vertical distance from the latter to the water in the suction well. The duty was thus dependent to some extent on the local exigencies in regard to piping. The De Laval Company's engineers originally estimated that the friction loss through the condenser, piping and fittings would not exceed 4 ft., but certain necessary changes from the original layout caused this loss to exceed 7 ft. The head actually overcome included the friction of the following apparatus and fittings: one 42-in. gate valve, one 45° bend, one water works type condenser, one 42 to 36 in. reducing nipple, one piece of 36-in. pipe about 8 ft. long, one 36-in. to 30-in. reducing long radius elbow for the suction side of the pump, and on the discharge side of the pump one 30 to 36-in. increasing long radius elbow, one piece of 36-in. pipe about 9 ft. long, one 36-in. long radius elbow, one 36-in. check valve, and one 36-in. gate valve.

During the test, readings of the suction and discharge pressures were also taken at the suction and discharge nozzles of the pump, and the total head based upon these readings was found to be 213.86 ft. Calculated upon the basis of work actually delivered in the water as represented by the product of pressure by volume, the duty would therefore be as follows:

Duty per 1,000 lb. of steam actually supplied, million ft. lb.	161.4
Duty per 1,000 lb. of steam corrected to specified superheat and pressure, million ft. lb.	168.3

This doubtless represents the highest duty so far obtained by pumping units of this type, and falls little short of the best results obtained with triple-expansion pumping engines costing, including foundations and buildings, very much more than the steam-turbine-driven centrifugal pump.

OPERATION RESULTS OF THE WATER PURIFICATION AND SOFTENING PLANT OF FARGO, N. D.*

By Frank La F. Anders, City Engineer, Fargo, N. D.

The Fargo water purification and softening plant has been in operation since June, 1912. The Red River of the North, from which the raw water is drawn, has a bacterial content ranging from 200 to 30,000 per cubic centimeter. The hardness averages 225 parts per million and ranges from 150 to 500. The stream flow ranges from 25 to 10,000 second-feet.

It was decided that the raw river water was impure, dirty, too highly colored, too hard, and that it had a disagreeable taste and odor. It was decided, also, that it could be best made into a satisfactory water for all purposes by rapid sand filtration with softening by lime and soda and the use of iron sulphate as a coagulant.

The plant uses the iron and lime process with the addition of enough lime to accomplish the desired degree of softening. During certain periods of the year soda ash is also used. Hypochlorite is used continuously, and is added just before the treated water passes onto the filters. The chemical solutions are added to the raw water by means of the Earl chemical rate controller. There are four of these all operated by a master controller, which is in turn actuated by the varying rates of velocity of the water in the raw water conduit. These controllers have been a marked success in this work at all times, feeding the chemical solutions in direct proportion to the amount of raw water flowing through the conduit.

In 1912, when the plant went into operation, the population was about 17,000. The recent directory shows a population of 21,102, an increase in the period of 4,102 people. Real estate men and others who are in close touch with the reasons for the shifting of population, claim that the increase is due to a great extent to the pure water supply that can at all times be depended upon.

At the time the plant went into operation, there were not to exceed ten meters in the city. The water works was then pumping to the city an average of 80,000,000 gal. per month. There were about 1,900 live services at this time. There are now about 2,650 services, of which 1,500 are metered and the average amount of water pumped to the city is about 60,000,000 gal. per month. The following tabulation collects these facts in a more compact form:

Year.	Population.	Services	Average pumpage per month.
1912	17,000	1,900	80,000,000
1915	21,102	2,650	60,000,000

The amount of chemicals used, in grains per gallon, averages about as follows: Sulphate of iron gr. gallon 1.3; lime, 8.0; soda, when used, 1.5; hypochlorite, .05.

---

*From a paper before the North Dakota Society of Engineers.

From the lime treatment, on an average, there is removed from the raw water about 50 per cent of the hardness of the water. Bacterial removal always averages in excess of 99 per cent and is as high as 99.6 per cent at times. An average of more than 95 per cent removal is obtained in the mixing chambers and settling basins. There are 14 bacterial samples taken from various parts of the plant, each day except Sunday, and determinations made from them, and in addition the necessary number of chemical analyses are made for controlling the coagulating and softening process. In addition to this, the chemistry department of the Agricultural College, which is located directly across the city from the plant, also makes a weekly analysis of the water as a check on the analysis at the plant.

There is no part of the operation of the plant that is more satisfactory than the softening operation. The average citizen thinks that the raw river water is unbearably hard as compared with the softened product. Let the hardness in the water delivered to the consumer run up 10 p. p. m., especially on Monday, which is wash day, and the operators are kept busy explaining why the water is so hard. In practical results there is a wider range than is indicated by the difference in the hardness in parts per million. It is almost impossible to soften the raw river water by soap in any reasonable time, while the softened water allows a soap lather to be formed almost immediately. The act of shaving is greatly simplified. The most marked saving, however, is in cleansing of clothes. The laundries report the soap bill reduced more than one-half, and the labor by which the laundry operations are carried on is reduced in a still greater ratio. There is also a saving in the wear and tear on clothes, especially those sent out to public laundries. Formerly it was not safe to send out clothes to the laundry if it was expected to have them all returned in good condition, and to have them last a normal period of life. Many complaints were made against the laundries because of the so-called rough method by which they destroyed clothes. This complaint is hardly ever heard now, for the reason that the softened water has eliminated to a great extent the laundry wear and tear on the clothes.

There is also a direct saving to the community in money, due to the fact that it is cheaper and more economical to soften the water in large quantities by the lime and soda process than in small quantities by soap. It is believed that the plant saves the community at least $7,000 per year by the process of softening the water 50 per cent.

During the early period of the operation of the plant, it seemed as if we were going to be bothered by after deposits in the mains and services. A great deal of trouble was experienced in the furnace coils and hot water lines. The deposits in many cases filled furnace coils at the rate of once or twice a year. Some large hot water lines filled up very rapidly. After the second winter, however, this trouble seemed less acute, and at present very little complaint is made about it.

A careful investigation of all the facts has led us to the conclusion that only a small portion of this trouble could be laid directly to the softening of the water by lime. Some of the facts upon which these conclusions were based are as follows: During the 30 years preceding the construction of the plant, the unpurified and unsettled water was pumped through the mains to the consumer. In the year 1911, about 10,000 ft. of 4-in. main was replaced by 6-in. main. The 4-in. main was reduced in area by the tubercles formed and the deposits from the water, from 20 to 40 per cent. There were occasions when specials were cut in on 6, 8, 10 and 12-in. mains, and in all cases there were found tubercles and deposits. During the past two years specials have been cut in on 6 and 12-in. mains and some 600 ft. of 4-in. has been replaced. Special examination of all these mains have been made to determine the interior condition of them. In every case the pipes are absolutely clean, the pipe coating appearing almost as clean as when new. The 12-in. pipe examined has been down about 16 years, and the 4-in. main about 20 years, and the 6-in. main about 10 years. During the first two years of the operation of the plant, all hydrants were flushed at frequent intervals and in all cases sediment was freely discharged with the water. The water would rarely clean up for two or three minutes and sometimes it would continue for five minutes. In some cases hydrants that were flushed once per week would at each flushing give forth a dirty turbid water with a very disagreeable odor. As the condition of the water in the mains gradually cleared up as shown by the hydrant flushing, the trouble from deposits in hot water pipes and furnace coils gradually became less. At the present time, and for some time, most all hydrants have shown a clear, sparkling, effluent, similar to the water in the clear well at the plant. In a few cases, iron rust stains the water for a few seconds, and then the water runs clear. These hydrants are all on dead ends where there is little or no circulation. We are continuing our investigation and observation in order to obtain as much light on the subject as possible for after-deposits in lime softening plants and distribution system are a source of a great deal of annoyance to the consumer and trouble to the operators of the plant.

The cost of furnishing water to the city through the present system, varies from 8 to 10 ct. per 1,000 gal. A typical illustration of monthly cost of operation per 1,000 gal. of water furnished to the city is that of the month of October, 1915, as follows: Filtration, 1.84 ct.; pumping, 2.96 ct.; water main maintenance, .54 ct.; accounting, .34 ct.; interest, .09 ct.; bonded debt, 2.68 ct.; depreciation, .64 ct.; total, 9.09 ct. per 1,000 gal.

The above charges form the total cost of operation of the plant for the various items enumerated. This analysis may more properly be called the cost of water works operation, for in it is included the cost of upkeep of the distribution system. The interest charge shown is that assumed on an investment in cash that the city had on hand at the time the plant was built. The bonded debt is the interest and sinking fund requirements on about $135,000. The total cost of the filter plant and pumping station was about $225,000.

Water is sold through the meter at a flat rate of 10 ct. per 1,000 gal. In addition to this there is a service charge, as follows:

Size of meter, in.	Service charge.
5/8	$0.40
3/4	.60
1	1.00
1 1/2	1.50
2	2.00
3	3.00
4	4.00
5	5.00
6	6.00

There are a large number of services still on the flat rate, but a late ordinance requires that all services be metered by Oct. 1, 1916. All new services must be metered before water is turned on.

The plant is maintained in a model manner. The grounds would be a credit to and are as well kept up as those of a private residence. Both filter plant and pumping station are painted throughout in clear white. The condition of the plant is very pleasing to the citizens of Fargo, who consider it one of the best if not the best asset that the city has.

Chlorination of California Waters.—There are now installed in California plants for water disinfection in the following cities: San Diego, Los Angeles, Pasadena, San Jose, Oakland, Berkeley, Sacramento and Eureka. Chlorination plants cost all the way from $450 to $1,200, depending on amount and kind of water to be treated and type of regulation desired. At a dose of 1 to 3 lb. of liquid chlorine per 1,000,000 gal. of water, costing at the present war price 20 ct. per pound, a water is secured as free of pathogenic organisms as it is possible to obtain. There is absolutely no detectable taste or odor produced by its use, probably the best proof of this being the experience of Pasadena, where the installation was not announced until a month after it had been in operation to determine whether the public could notice any real difference in the palatability of the water.

Engineering and Contracting

Devoted to the Economics of Civil Engineering Design
and to Methods and Cost of Construction

EDITORS
H. P. Gillette C. S. Hill C. T. Murray S. C. Hadden C. W. Malcolm

Volume XLV. CHICAGO, ILL., APRIL 26, 1916. Number 17.

NEW DATA ON ACTIVATED SLUDGE.

In this number we publish two articles pertaining to the treatment of liquid wastes by the activated sludge process. The first relates to the treatment of sewage at the Milwaukee experiment station and the second relates to the treatment of the liquid wastes from the Chicago Stockyards and Packingtown in a small experimental plant.

The Milwaukee article contains analytical data on the performance of the activated sludge plant during the recent winter months, and also gives data on the sludge produced. These data are new, having been observed since the publication of the second annual report of the Milwaukee Sewerage Commission.

A perusal of these articles will show that the early promises of this interesting method of sewage treatment are being realized. Of particular importance is the conclusion, reached by the Milwaukee experts, that at winter temperatures good bacterial removal and clarification can be maintained. About 90 per cent of the suspended matter and of the bacteria were removed. The low temperature, of course, retarded the oxidation of organic matter and decreased the stability of the treated liquor. But by increasing the amount of air used the figure given was attained. At times the sewage temperature dropped to 34° F. It appears that the liquor depends upon nitrates for its stability in the summer and upon dissolved oxygen in the winter.

The sludge produced at Milwaukee, during the winter, can be dried from 98 to 75 per cent of water. The sludge is easily handled and has a steady market at a good price.

A NEW TYPE OF EARTH DAM CONSTRUCTION.

A new type of dam in American engineering practice is illustrated and described in another column of this issue. It may be called a flood retarding dam. Unlike the ordinary dam it impounds only flood waters. In times of normal flow it does not act; when flow exceeds the normal by any amount greater than the channel below the dam can carry without overflowing the dam begins to act to impound the excess. The dam is a flood protection structure solely. It serves no purpose, except possibly as a bridge across stream, unless flood occurs. Then it operates automatically. These features differentiate the new type completely from normal dam structures for water power and water supply.

PAVED HIGHWAYS AND NATIONAL DEFENSE.

Civil engineering is the offspring of military engineering. Though long trained to gentler tasks the child is manifesting much of the spirit of his parent. Organizations are being formed, lectures are being attended, and books are being studied by the civil engineer to the end that he may know how to serve in war. Those of our engineering journals whose avidity for the thing that is newest is their distinguishing quality are catering most excellently to the appetite for knowledge of battle tactics suddenly developed by the civil engineer. The civil engineer is most intensely interested in the means and methods of the military engineer. This is natural, entirely logical and a very good thing. Though long beyond the active service age, the editor has just finished the reading of a book on "Military Preparedness and the Engineer." He makes this confession both to indicate that he is not immune to war fever and to explain his decision to violate for one issue the devotion of these columns alone to the study of peaceful engineering pursuits.

On another page is published a short article on the utility of highways in war. It is believed that this article is wanted to counteract much foolish talk of certain highway propagandists. It is becoming, because of their increasing numbers, rather difficult to recall all the "national" roads bearing famous names that have been inaugurated in the last few years, but for one and all one easily remembers the resounding demand made for support on the plea of military preparedness. The skilfully drawn picture of millions of men with muskets marching up and down and across the continent by these roads to meet and resist invading armies is of course too silly for consideration, but not so silly that it will fail to make impression. Therefore it is good to have one who knows of the real utility of roads for national defense tell plainly and without buncombe of what this utility consists. We suggest that the most civil of our civil engineer readers shall read Major Bond's article on a succeeding page.

THE REJUVENESCENCE OF THE COUNTY ENGINEER.

The office of county engineer is old. In some states the title was county surveyor. As a marker of boundaries the county engineer or county surveyor, of a departing generation performed skilled service. When settlement became complete and land ownership was confirmed and became permanent the marking of boundaries offered small employment. No labor in engineering of like importance calling for legal sanction succeeded and the county engineer's position bulked smaller and smaller until it offered little to ambitious engineers. This has remained the condition for a number of years until within a few years very recently. Now duties have lifted the county engineers' work again into prominence. He is now in most states the official technical director of county highway construction.

As director of road construction the county engineer has a task equivalent in importance to that of the city engineer. The sums expended, under his direction are always considerable and are often very large. Counties are numerous in which the road expenditures for the present year will reach five figures and those in which the total exceeds a hundred thousand dollars are by no means few.

CONCERNING PRESENT METHODS OF RUSHING BUILDING DESIGN AND CONSTRUCTION.

One marked tendency of the average prospective building owner is to start an insistent demand for excessive speed in design and construction as soon as the designer is engaged. The result is that there is unwarranted haste in every subsequent step incident to the turning over of the completed structure. Present methods are largely wasteful of time and money, and in many cases great haste is unnecessary. We believe architects and engineers have it within their power to correct many of the evils incident to undue haste in design and construction by carrying through a systematic campaign designed to educate prospective building owners to the absolute need for more time in design and construction. No intelligent designer is anxious to rush a job on which he is engaged, nor is any one designer able to bring about a change in existing conditions—by concerted action, however, we believe much good can be accomplished.

The ordinary procedure is about as follows: First the designer is asked to get out preliminary plans and an estimate of cost, or several plans and estimates of cost, within a few days. The result is that, if the job is a big one, the whole office force immediately begins to work overtime, and, in addition, new men—not accustomed to the methods used in that particular office—are engaged temporarily; and later dismissed summarily. In the meantime the architect's engineer, or some consulting engineer engaged for this job, is set to work to design a framework for a building which exists only in the architect's imagination, although at this stage there are available a few sketches which the architect is certain to change before he finally creates something which apparently satisfies him. It may be pertinent to add that the engineer tries conscientiously to produce a skeleton which will hold up the useful and necessary parts of the building, together with its embellishments and superficial features, for each new conception of the architect. His success in doing this depends largely upon his luck at guessing. In the meantime the architect is kept busy dodging contractors and material men who have heard of the contemplated work and desire advance information. After the plans and specifications are completed each bidder is given about ten days to make an estimate (?) of quantities and of what the work is worth to him, taking into account the existing condition of his affairs. The same rush and confusion exists after construction is started, and there is certain to be numerous occasions for conflict between the various subcontractors.

Enough has been said—lightly, yet seriously—to indicate to those not entirely familiar with building construction work some objections to the present hasty methods in design and construction. The wonder of it all is that the owner gets as good a building as he generally does. If he obtains an entirely satisfactory job it is reasonably certain that he has done so at the expense of those who have had charge of its design and construction, which, of course, is unfair. If the owner gets a poor job it is partly his own fault, but only partly so, as he generally does not appreciate the difficulties which must be overcome before the completed building is turned over to him. The solution, we assert, is an educational campaign conducted with the co-operation of all architects and engineers engaged in this kind of work. And such a campaign is well worth while.

CONCERNING THE MINIMUM THICKNESS OF METAL IN STEEL HIGHWAY BRIDGES.

Presumably under the assumption that highway bridges take much lighter loads than do railway bridges, and are less subject to impact forces, standard steel bridge specifications require a $^3/_8$-in. minimum thickness of metal for railway and only a 5/16-in. thickness for highway bridges. This specified minimum thickness of metal has its greatest effect on certain bracing and auxiliary members which carry only nominal stresses, although it often influences to a considerable extent the manner in which the required area of many of the main sections is disposed. If both types of bridge were kept equally well painted this specification would be a logical one, but, as we all know, the painting of railroad bridges is usually done in a systematic and efficient manner, while highway bridges generally receive scant attention after they are erected. The reasons for this are apparent and need not be mentioned here. Under prevailing conditions, and these conditions are not likely to undergo radical change in the near future, it is much easier to obtain funds for new highway bridges than it is to provide for the proper maintenance of old ones. Moreover, bridges on important highways now take much more traffic and much heavier loads than formerly, and it is desirable that those steel bridges used on our improved highway systems be more nearly permanent than in the past.

In view of the above conditions we believe engineers are justified in using a $^3/_8$-in. minimum thickness of metal on important trunk-line steel highway bridges instead of the customary 5/16-in. thickness. Bridges are an exceedingly important part of an improved highway system, and an increase in the minimum thickness of metal appears to be a step in the right direction.

COMMENT ON SOME MINOR COST ITEMS OF CONCRETE ROAD CONSTRUCTION.

Published costs of concrete road construction appear profuse until one begins search for separated costs of minor processes. One who seeks to learn from published records what it has cost in a number of instances to supply water, for example, for the construction of concrete roads will gain little knowledge. The same thing is true if one seeks to learn what it has cost to roll subgrade, to spread the curing blanket of earth, to remove this blanket, to clean the concrete for bituminous carpeting, to spread stone chips on the bitumen. These facts are so easy of self-demonstration by anyone interested that it is needless to cite illustrations. The reasons for the facts are the important things to consider.

Basically the reason is that cost analysis and synthesis is in construction work practiced very crudely: Lumping and averaging are inherited practices of the construction business. Broad operations and not constituent processes are the terms in which the constructor counts. Some of the costs of the minor road building processes named above, when divided into square yard or cubic yard units, are small. The impulse of habit is to lump a number of them into one item or to include each with some other larger item. Water costs are, for example, almost invariably lumped with cost of mixing. "Grading" is a similarly inclusive term for perhaps half a dozen processes, all of which or only one of which may be necessary on any specific work. "Curing" again includes the several processes of shading with canvas, covering with earth, sprinkling and removing earth cover. One readily concedes the greater convenience of such lump items, but it is likely to prove a costly convenience unless carefully regulated.

In another place in this issue there are published at unusual length the costs of some experimental concrete road construction in Philadelphia. These costs are notable in giving segregated costs of numerous processes seldom separately itemized. From these minor cost items are selected the following costs per square yard:

Shaping subgrade. Ct.	Rolling subgrade. Ct.	Covering concrete. Ct.	Removing covering. Ct.	Pipe line. Ct.
7.56	0.37	0.57	0.32	0.39
9.72	0.51	0.45	0.43	0.77
7.86	0.28	0.52	0.21	1.40
6.80	0.33	0.79	0.16	0.72
9.84	0.40	0.48	0.26	0.85

Multiply any one of these items by six and we have approximately the cost per cubic yard of concrete produced. As an illustration of possibilities let us add the maximum costs and also the minimum costs and compare them. The result follows:

Maximum cost per cubic yard	77.82 ct.
Minimum cost per cubic yard	48.78 ct.
Difference	29.04 ct.

Obviously this is an extreme illustration, but it serves excellently to demonstrate the fact that separate recording of minor cost items is not a needless requirement. And these figures do not represent extremes of variation. Instead, they are all from the same two-mile stretch of concrete road, and may be safely concluded to run unusually regular. To select an illustration of more extreme variation one may take the cost of water supply for concrete road work. The editor knows of work in which the cost of water per cubic yard of concrete was

6 ct. and another case in which it exceeded 50 ct., and water at the source cost nothing in either case. The difference lay entirely in the greater amount of water required in one case than in the other and the greater cost of getting water to the work in one case than in the other. Lumping water cost with cost of mixing in concrete road construction is a particularly dangerous practice.

In our issue of April 5 was published a blank form for reporting costs of concrete road construction. This form, if followed, will give road engineers far more useful costs than they have possessed, but for his own instruction the builder needs a greater segregation of costs than is here proposed. As an illustration, labor on subgrade is a single item. As this will ordinarily be reported, what will it mean? The answer is: It will mean precisely nothing unless explained in detail. At another time space was given to a more extended consideration of subgrade preparation as its meaning is comprehended in concrete pavement construction. For the moment it is mentioned merely to illustrate the folly of lumping in one item costs of several processes any one or all but two of which may not be required in any specific instance.

THE LIFE OF STEEL FREIGHT CARS.

Steel freight cars have now been long enough in use to make it possible to estimate their average natural life. Mr. M. K. Barnum, in a recent issue of the Railway Age Gazette, says that the oldest steel freight car of which he has knowledge was built in 1896. Two years ago it received a new floor, beside other extensive repairs, and appearances indicate that it may be good for at least 10 years more. However, this car seems to be an exception, and he puts the average life of steel gondola and hopper cars at about 16 years.

The short life of steel cars is largely due to corrosion of the steel plates. Cars in service near salt water corrode more rapidly than elsewhere. Idle cars corrode much more rapidly than those in use, two months of idleness being equivalent to about two years of use. Frequent painting—every three to five years—prolongs the life 25 to 50 per cent, but relatively few steel cars have been painted.

It is a somewhat astonishing thing to hear that steel cars have a shorter life than wooden cars, yet Mr. Barnum's data seem to indicate that fact. May it not prove wise to use pure iron instead of steel for the floor and side plates of metallic cars?

WITHHOLDING THE WORD OF COMMENDATION.

A prominent engineer, who studies engineers as well as engineering, states that as a class they are prone to withhold the word of commendation. More specifically, he states that engineers seldom write a brother engineer to congratulate him on the exhibition of a high degree of professional skill. Is this failing a species of professional jealousy? In some cases, yes; in most cases, no. Engineers simply have not formed the good habit of praising a contemporary when he carries some exceptionally good piece of engineering to a successful conclusion. The habit might well be cultivated.

It requires but a little effort to write a man an appreciative letter touching on some professional accomplishment of real significance to the profession as a whole or to any considerable part of it. Such praise is appreciated. The praise of incompetents is not valued by the man who is fair with himself, but the praise of competents is highly appreciated.

Whether a man be an engineer, an editor, or whatnot, the praise that pleases and inspires him to greater efforts is that bestowed by other men engaged in his line of work. Thus the writer always wears "bachelor buttons" in his shirt front as a form of preparedness against the day of his receiving praise from a colleague. These buttons and their fastenings, be it known, are wholly metallic—they are put on by means of a hammer and an anvil, flat-iron or other relatively immovable body. They can be depended upon to withstand the most sudden and violent chest expansion.

Only engineers are competent engineering critics. Praise from them only is worth while. How unfortunate, then, that this praise should be withheld when it is due.

EDITORIAL PARAGRAPHS.

The visitor from Mars today could be easily pardoned for thinking that in our strange language there were three words—pacifism, preparedness and co-operation—of a potency greater than lay in other words. If he were one of H. G. Well's Martians of scientific attainment and as would be natural foregathered much with engineers he might also imagine the word co-operation to be the distinctive magic of the tribe of builders. Its magic potency also he might pardonably assume lay entirely in utterance.

That writer of frequently curious power, Jack London, in his strange imagining of "Before Adam" tells how the Rock People concerned with encroachment on their means of livelihood by the Fire People were wont to meet in doubtful council to canvass ways of rescue. After brooding long and ineffectually always from somewhere in the crouched mass would arise the shout "Ula-Ula." Brightening up, one after another took up the cry and screamed it happily until exhaustion and sleep overtook all. Shouting "Ula-Ula" met all mental requirements. Sometimes one thinks that co-operation is the Ula-Ula of engineers.

This journal is not belittling any effort toward cooperative work by engineers to enhance their standing as professional men. Long before the idea had reached its present condition of a propaganda the editors were urging action. They are still urging action—not talk.

The engineer is an iconoclast. One after another the gods of tradition and legend are cast down by him. For years tradition has held that the famed Cascades of the Oregon were formed by a prehistoric natural bridge which finally fell into the river and formed a dam and rapids to obstruct its former free flow. Engineers studying the site of the Cascades for water power development have recently demonstrated that no such great arch could have been possible because "a suitable abutment exists only on the north side of the river." Tradition must watch out for its abutments if it is to pass the censorious eye of the engineer.

On the other hand, while discrediting a dam and rapids created from the ruins of a fallen Bridge of the Gods, the engineers who have been studying the Cascades give us as their origin a scarcely less marvelous cause. They say: "There is every required evidence to indicate that an enormous rock avalanche once came from the breaking away of an immense volume of the mountains now represented by the remnants known as Table Mountain and Red Bluffs, and that this rock slide more than obstructed the river by a natural dam. It actually entirely buried the old channel and forced the river up on an adjacent rocky bench and over against the mountains bordering the south side of the valley." Calculations by the observing engineers place the volume of this slide as not less and probably much greater than a billion cubic yards. This is enough rock to fill the Panama Canal three times full.

Among the numerous instruments of warfare attributable to American inventiveness we failed, a few weeks ago, to mention barbed wire. First made to keep cattle from breaking out, it has come now to be mostly used to keep men from breaking in.

EFFECT OF DURATION OF MIXING PERIOD ON QUALITY OF CONCRETE.

To the Editors: Referring to tests on concrete mixed 3 minutes showing less strength than concrete mixed 1.5 minutes mentioned in your issue of April 19th on page 361, you are right in saying these data are more suggestive than conclusive.

The writer during the past year made a number of tests and found the results varied with the amount of water used. The longer the concrete was mixed the more plastic it became, for the effect of long time mixing is to distribute the water through the mass.

Using identical amounts of water in all the batches tested it was found that the decrease in strength was progressive with increased time of mixing. By using less water in the long time mixed batches the strength increased progressively. With stone containing from 1 to 2 per cent of moisture and sand containing from 5 to 7 per cent of moisture it was found that a 1—2—4 mix with 4 lb. of water per cubic foot of loose materials produced concrete mixed 3 minutes having a strength equal to concrete mixed 1 minute containing 5.5 lb. of water per cubic foot of loose materials. The consistency was that of a soft tooth paste. The cylinders were tested at the end of 30 days.

When the water was increased to 7 lb. per cu. ft. of loose materials there was a marked falling off in strength, the concrete being a thin soupy consistency. A sloppy consistency resulted in a still smaller strength, far greater relatively than the increase in amount of water. It was most marked in long time mixing.

The agitation in favor of wet rather than dry concrete commenced when reinforced concrete became popular in the days when cement was coarsely ground. In the present time when extremely fine grinding of cement is the rule there should be a return to the use of less water, not, however, to the old-fashioned dry mix. A 3-minute mix with considerable water doubtless "kills" considerable fine cement, which then becomes in part an inert void filler and in part appears on the top as laitance.

Yours truly,
ERNEST M'CULLOUGH.

RETARDING BASIN PLAN OF FLOOD CONTROL FOR DAYTON, O., AND THE MIAMI VALLEY.*

By Arthur E. Morgan, Chief Engineer.

The recommended plan consists of a series of five retarding basins, located as shown on the map, Fig. 1, supplemented by channel improvements through the cities. The retarding basins will be formed by dams built across the valleys of the Miami, Mad, and Stillwater rivers, and on Twin and Loramie creeks. Each dam will have permanent openings through its base through which the ordinary flow of the river and the flow during ordinary freshets will pass unimpeded. During large floods the water which cannot pass through the outlet conduits will be held back temporarily in the basins above the dams. The conduits are proportioned so that no more water can pass through them than can be carried safely in the improved channels through the cities below. In this manner, the runoff of a flood like that of 1913, which lasted but two or three days, would be distributed over a period of about two weeks and its height would be correspondingly reduced.

Action of Retarding Basins During Large Floods.—When a large flood occurs the retarding basins will fill rapidly at first because at the lower levels the storage capacity is very small. Later the level will rise much more slowly both because the storage capacity increases very rapidly at the greater depths and because with the increased head on the outlet conduits their discharge is correspondingly increased. Towards the end of the flood the water level changes more and more slowly until it finally becomes stationary at the highest level reached. It will continue to rise, however, as long as the amount entering is greater than the amount of the discharge from the conduits.

As a flood in a river subsides much more slowly than it rises, it will be a considerable time after the occurrence of the crest of the flood in the river above the retarding basin before the amount of water entering the retarding basin will have fallen to an amount equal to the discharge from the outlet conduits. The time of greatest elevation in the retarding basins, therefore, will occur after the time of the crest of the flood in the river above the retarding basin.

Height of Dams and Size of Outlet Conduits.—The next step in designing the retarding basin system is to fix the height of each dam, and the size of the outlet conduits through the dam. The process of doing this is as follows:

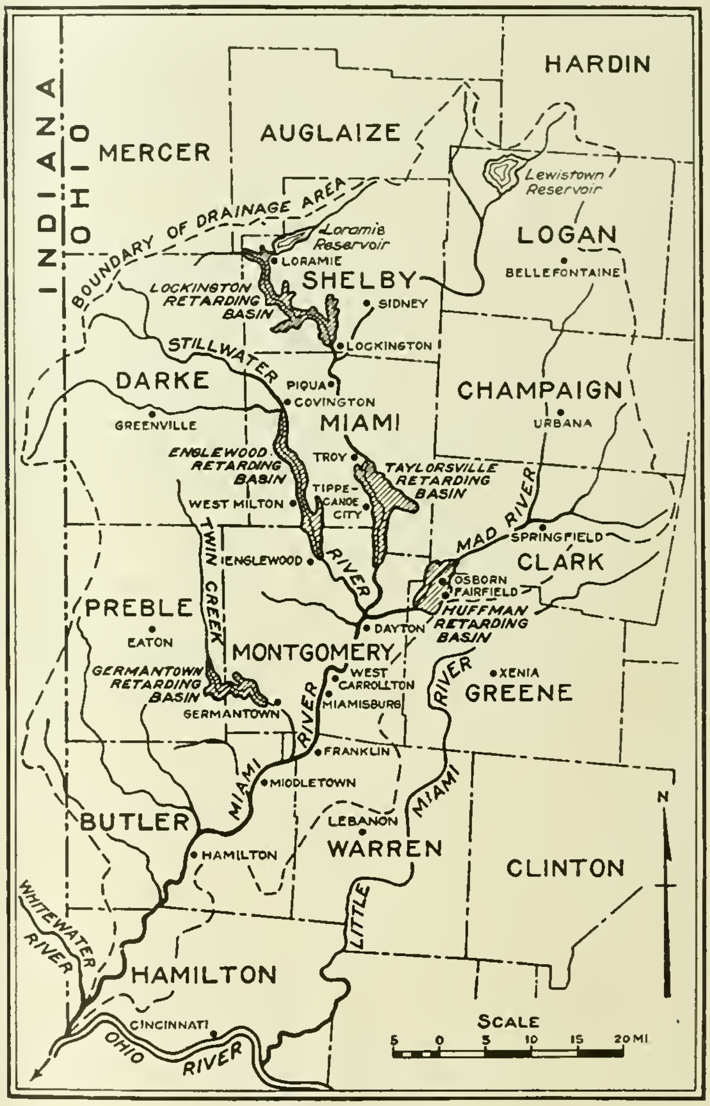


Fig. 1—Map of Miami Drainage Area Showing Location of Proposed Retarding Basins.

With the assumed maximum runoff of 10 in. occurring in three days, the total runoff in acre feet above a dam site is equal to five-sixths of the number of acres in the tributary drainage area. This gives the total quantity of water that the retarding basin, in order to provide the desired margin of safety, must be capable of handling in three days, either by storing it, or releasing it through the outlet conduits. In other words, the sum of the amount stored in the retarding basin and the amount flowing out through the conduits in three days must equal the total 10-in. runoff.

If we then assume a tentative elevation as the maximum height to be reached by the water within the retarding basin, we obtain at once from the capacity curve the total amount of water stored in the retarding basin at this time. Deducting the amount so stored, from the total runoff leaves the amount which must be discharged through the outlet conduits.

---

*Extracts from the chief engineer's report to the Miami Conservancy District.

By numerous trial calculations, it was established that for every sudden intense runoffs, such as our assumed maximum storm, in retarding basins of the shape and capacity of ours, the average rate of discharge through the conduits, during the three days of filling the retarding basin, is very nearly five-sixths of the maximum rate of discharge through the conduits when the retarding basin is full.

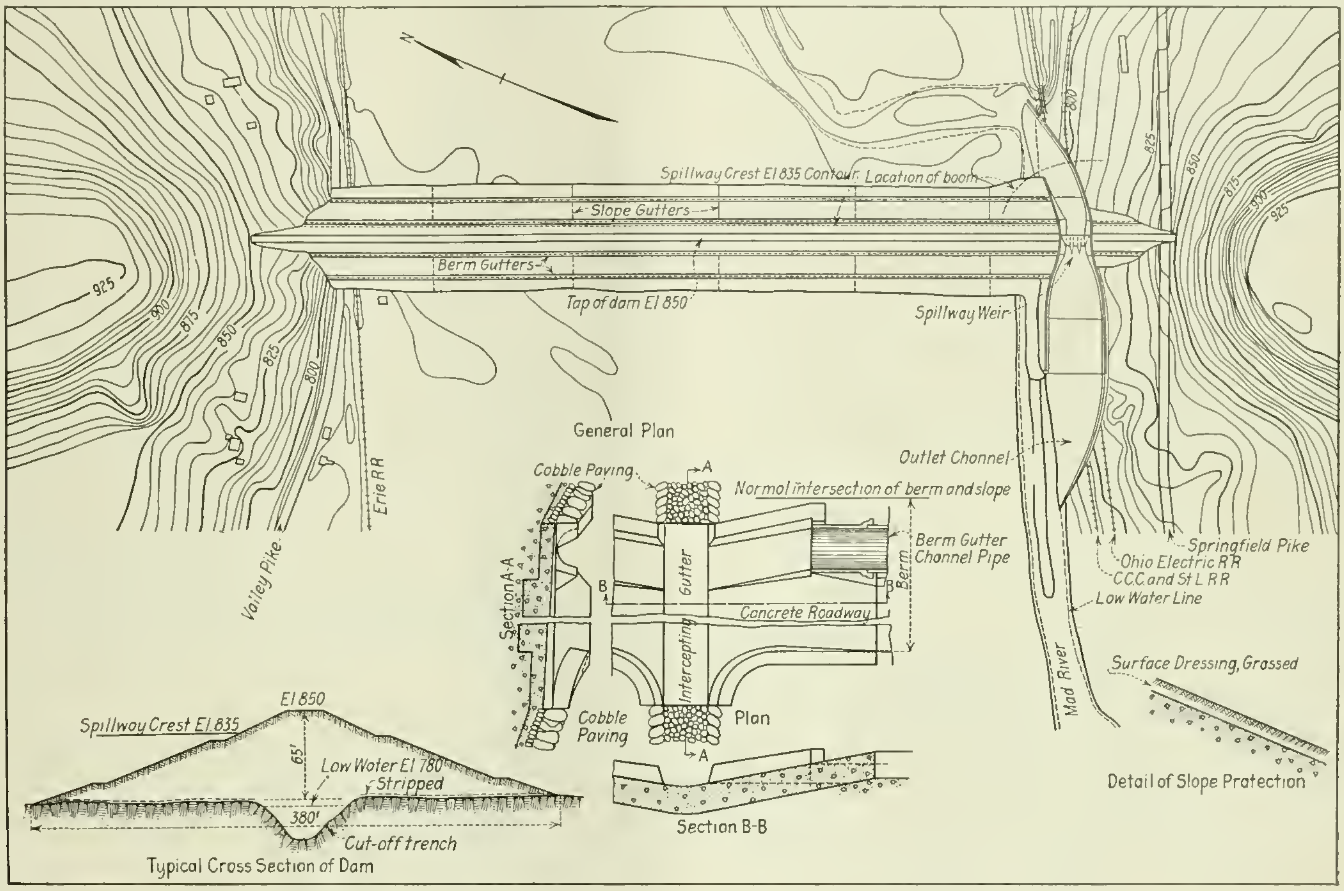


Fig. 2—Plan, Section and Earth Dam Details, Huffman Retarding Basin.

Hence, knowing the total amount of water to be discharged through the conduits, the average rate of discharge during the three-day period can be calculated, and then by multiplying by six-fifths, we have the maximum required outlet capacity. From this the dimensions of the outlet conduits are determined.

This process was used in all the retarding basins. Various maximum elevations of water surface were taken and the corresponding sizes of the outlet conduits calculated. By means of these, the final sizes adopted were selected. It was necessary to keep the sum of the discharges from the various retarding basins down to such quantity as could be safely taken care of in the improved channel through the cities below.

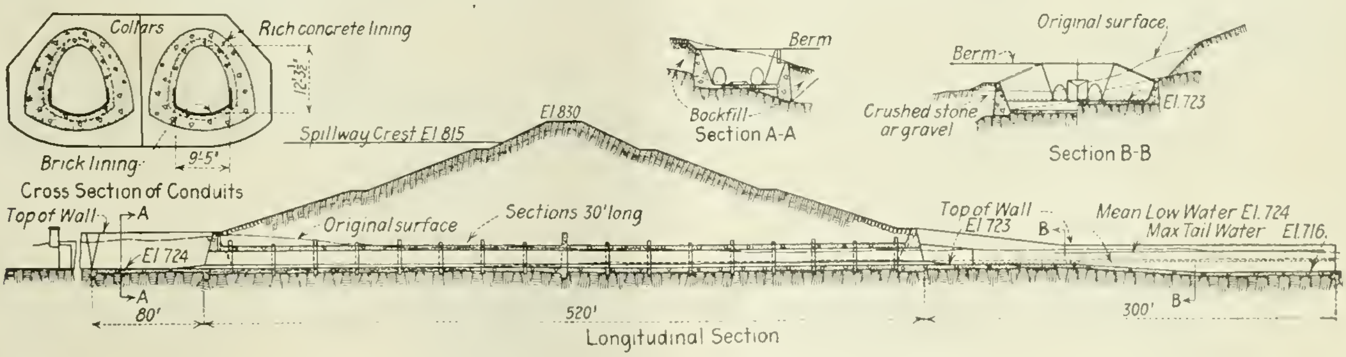


Fig. 3—Details of Outlet for Germantown Retarding Basin Dam.

In those retarding basins where there is abundant storage capacity available, such as at Germantown, Englewood, and Lockington, the dams could have been made higher than the ones recommended, if there had been any reason for so doing, or the outlet conduits could be made as small as desired. But considerations other than their capacity to hold back flood water make it undesirable to have the outlet conduits too small. In fixing upon the minimum size of these outlet conduits, factors taken into consideration were the frequency and height of small floods in the retarding basins and the time of emptying the basin after a large flood.

If the outlet conduit should be too small, frequent flooding would occur in the bottom of the retarding basin during small rises in the stream. The time required to lower the water a certain distance in the retarding basin would vary exactly inversely as the capacity of the outlet conduit, provided there were no inflow into the basin during the same period. When the outflow is only slightly greater than the inflow, any small increase in the outflow would hurry the rate of emptying in an entirely disproportionate degree. Hence, a small increase in the size of the outlet conduit, which might have no importance in the degree of control of a large flood, could very much reduce the time required to empty the retarding basin after the large flood.

For a large flood, when the capacity of the outlet conduit is small compared with the natural flood flow, a moderate change in the size of the outlet conduit has no appreciable effect upon the degree of flood control, and hence the size of the small conduits has been fixed chiefly with reference to their effect upon small floods and their effect upon the time of emptying the full basins.

Careful study has been given the matter of adjusting the heights of dams and sizes of outlet conduits for the different retarding basins, so as to secure for the system as a whole the most satisfactory and efficient operation, with the least expenditure of money and disturbance of vested interests.

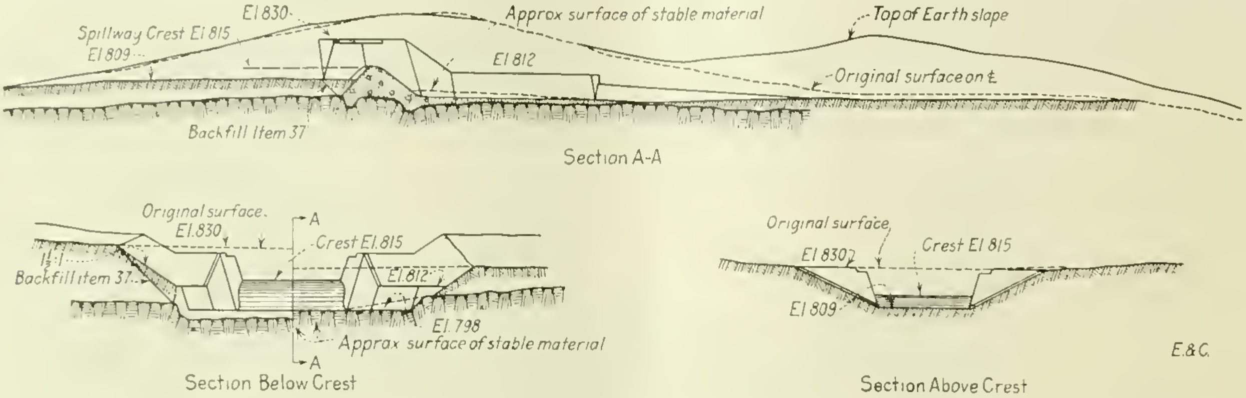


Fig. 4—Details of Spillway for Germantown Retarding Basin Dam.

Spillways.—Each dam is provided with a large overflow spillway near its top. These spillways probably never will come into use. If a flood should occur so far greater than any on record as to fill the retarding basins to an elevation higher than the spillway crest, the excess water would be discharged over the spillway. In such a case the amount flowing down the channel below the dam would be increased, and the security against damage in the cities below would be correspondingly diminished.

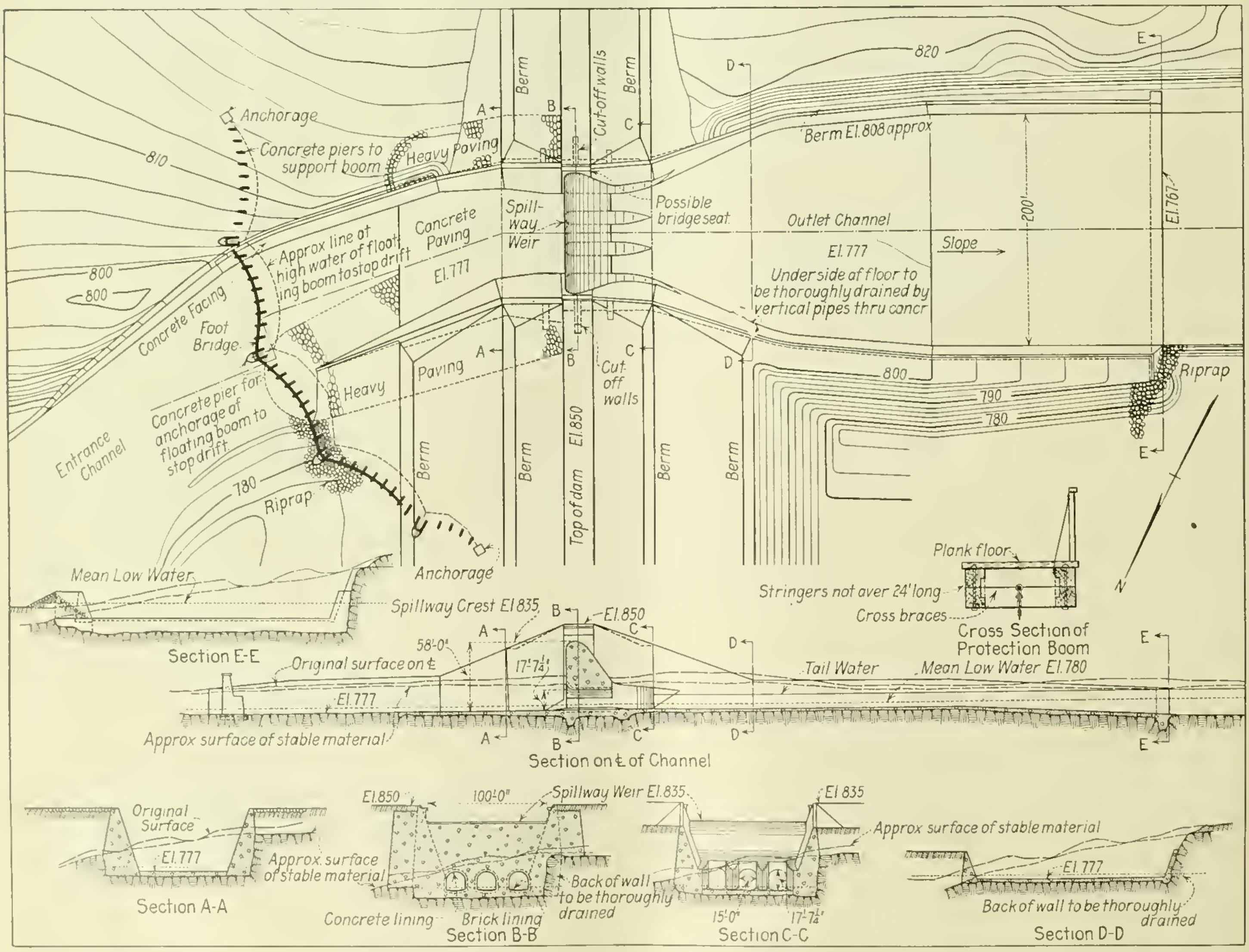


Fig. 5—Details of Spillway and Outlet for Huffman Retarding Basin Dam.

The dams and spillways are so designed as to care for a flood twice as great as the greatest on record, just as though such a flood were to be of common occurrence in the future.

Hence, if a storm could occur great enough to fill the retarding basins above the spillway crests, the dams themselves would be protected against any possible damage by the spillways discharging the surplus water. Thus the dams would be perfectly safe against damage, even though there should be damage to lands below from the excess flood water flowing down the channel. But even in this imaginary case, the damage below would be much less than would occur if the dams were not in existence. That is, even in such a case the retarding basins would afford a large measure of protection.

It should be remembered as a cardinal principle that the maximum efficiency of a flood retarding basin is secured when the work is so designed that during the maximum storm to be provided against, the water in the basin approximately reaches, but does not materially overtop, the spillway. In designing the spillways, it was decided to make them large enough so that with the given storage capacity in the basin, a maximum runoff of 14 in. in depth over the tributary drainage area in three days could be taken care of. This is twice the amount of the 1913 flood runoff.

In calculating the discharge over the spillway crest, it was assumed that the maximum level of water reached in the retarding basins under this 14-in. runoff would be about 10 ft. above the level of the spillway crest. The sum of the storage capacity and the amount discharged through the outlet conduits was subtracted from the total 14-in. runoff to obtain the amount that must be discharged over the spillways. This gave a smaller size for the spillway for the Huffman basin than it seems desirable to use, and therefore it was decided to increase the length of this spillway to 100 ft.

Construction of Earth Dams.—The dams themselves are to be built of earth, Fig. 2, probably by a hydraulic process, so as to secure an impervious central portion, of the most approved type of construction. The slope of the faces of the dams has been very conservatively fixed.

The level top of the dams will be 25 ft. wide. The side slopes will vary, being 2 horizontal to 1 vertical at the top, and 10 horizontal to 1 vertical near the base. At the breaks in the slopes there will be level berms 10 ft. wide. These berms will be provided with drains or ditches, leading rain water off to the sides of the dam, so it will not flow directly down the face.

Construction of Outlet Conduits.—The outlet conduits through the dams will be built of massive concrete. The interior surfaces will be carefully finished smooth, so as to offer as little resistance as possible to the flow of the water. The entrance end of the conduits will be rounded with large radius curves, and with no sharp angles whatever, so as to avoid entrance contraction and disturbance. It is assumed that with sufficient care in this regard the entrance coefficient will be unity.

The entrance will be protected from the approach of any possible drift by rows of piers and a continuous boom. At the time of the occurrence of any considerable flood the entrance to each conduit will be submerged, and therefore free from disturbance by floating drift.

With a high stage in the retarding basins, water will issue from the conduits at a high velocity. It is necessary to protect the channels below the dams from injury by this high velocity, and the outlets of the conduits are so designed that the energy of the water will be dissipated in a standing wave within a concrete channel.

Construction of Spillways.—The spillways will be built of concrete with rounded crests of such shape as to secure a maximum weir discharge when the water in the basin approaches the assumed maximum level. A channel protected with concrete will extend from the spillway crest to the valley below, so located and constructed as to prevent any possible injury to the dam by descending water, should the spillways ever come into action.

Figures 3 and 4 show the arrangement of the Germantown dam, outlet conduits, and spillway, giving a general plan of the whole and on a larger scale a plan and elevation of the lower end of the outlet conduits. The earth dam is built across the valley at a narrow place between projecting hills on the north and south sides. The general plan shows the relation of the dam to the contour lines along the sides of the valley, and the level berms on the slopes of the dam.

The concrete outlet conduits through the base of the dam are on solid rock on the north side of the creek bed. The concrete spillway is located in a notch in the hill about 500 ft. north of the dam. Detailed plan and elevation of the lower end of the outlet conduits, drawn to a larger scale, show the shape of the cross section of the two equal horse shoe-shaped conduits. They are made parallel, about 40 ft. apart, and empty into a single tapering concrete channel leading to the creek bed below the dam.

In the Englewood dam the arrangement is much the same as at Germantown, but at the other three dams the spillways and outlet conduits are combined into one concrete structure. The Huffman dam has been chosen to illustrate this arrangement.

Figures 2 and 5 show a general plan of the Huffman dam, spillway, and outlet conduits with an enlarged plan, elevation, and longitudinal section of the combined concrete spillway and outlet conduits. The concrete spillway weir is located on solid rock near the Mad River channel on the south side of the valley. Through the base of the structure pass the three equal horse shoe-shaped outlet conduits. The entrances to these conduits will be rounded so as to facilitate the flow of water as much as possible; and the conduits empty through carefully tapered channels into a single combined passageway leading back to the river bed.

CONCRETING METHODS IN NEW YORK STATE CONCRETE ROAD CONSTRUCTION.*

By W. M. Acheson, Division Engineer, Commission of Highways, Syracuse, N. Y.

On the roads which have been constructed in New York State, with one exception the material has been delivered on the finished subgrade in windrows, the stone on one side and the sand on the other; care has always been taken that these materials should never become mixed before proportioned for the mixture.

An improved type of mixer is used and the batches have been from 2 to 4 bags to the batch, the bag being generally taken as the basis of the loose material.

The organization has generally been, one man sprinkling and throwing on cover, one man smoothing, two men on the screed, three men in front of the mixer spading the concrete to conform as nearly as possible to the section required, and two operators on the machine—one on the supply bucket and one depositing the concrete. Behind the machine are from 15 to 20 men, depending absolutely upon the life which the foreman in charge instills into his gang.

The materials are so distributed that the wheeling distance is as short as possible at all times, and by this I mean 50 ft. from the mixer.

The material coming from the concrete mixer should be deposited so it is of such consistency that the mortar does not run away from the coarse aggregate.

The material as deposited is handled by three men in front of the mixer, in order to make the screed do as little as possible.

The finishing should always be within 10 to 15 ft. of the screed, and this is impossible if the concrete is too wet.

At the joints a split float should be used in order to insure the road having a continuous plane for the finished pavement.

I advocate the brooming of a concrete road for the reason that the marks which the broom makes in the pavement aids in holding the moisture longer during the curing season.

Care should be taken, however, to see that the broom marks are not too deep so as to start spalling and impede the surface drainage.

Our roads are covered with loam, sod or any soft material and wet down twice a day in the hot summer. In the fall we have constructed pavements which we placed no cover on at all, but were wet down at least once a day.

One of the most important parts of a contractor's road plant in the construction of cement concrete roads is the water supply. I would advise at least a 5-HP. engine with a pump capacity of at least 200 gal. per minute. The pipe line should be at least two-inch pipe, and should have tap at least every 200 ft. Wire-wound hose should be provided long enough to reach half way between the taps. A great many mistakes have been made in the past in regard to this particular feature.

---

*Extract from a paper read before the American Concrete Institute.

WINTER EXPERIENCE WITH THE ACTIVATED SLUDGE PROCESS OF SEWAGE TREATMENT AT MILWAUKEE.—SLUDGE DISPOSAL.[*]

By William R. Copeland, Chief Chemist, Milwaukee Sewage Testing Station.

In winter the temperature of the Milwaukee sewage averages about 51° F. with occasonal drops to 40° or less when melted snow enters the sewers.

These low temperatures, especially the latter, retard oxidation of organic matter and decrease the stability of the treated liquor. By applying 2¼ cu. ft. of air per gallon of sewage the continuous flow plants removed 90 per cent of the bacteria in the Milwaukee sewage and reduced the suspended matter to about 15 parts per million.

The sludge formed contained about 5 per cent of nitrogen calculated as ammonia, 1¾ per cent of available phosphoric acid and 0.4 per cent of potash.

This sludge can be recovered by pressing without the use of lime.

The Milwaukee Sewage Testing Station stands upon the shore of Lake Michigan and is exposed to the full rigor of this northern climate. During January and February the thermometer registered below zero on nine days and dropped to 15° below at the coldest period. The sewage temperature dropped with the approach of winter from 67° F. in September to 50° F. in January, but the zero weather did not reduce it further. When melting snow water entered, however, the temperature of the sewage dropped for several hours at a time to 43° F. and on a few occasions registered only 34° F.

TABLE I.—AVERAGE DAILY ANALYSIS OF SEWAGE BEFORE AND AFTER TREATMENT BY THE MILWAUKEE CONTINUOUS FLOW ACTIVATED SLUDGE PROCESS AT FALL AND WINTER TEMPERATURES.

Source of sample.	Month.	Temperature, degrees F. Air.	Temperature, degrees F. Liquor.	Average number of— Gallons of sewage treated.	Average number of— Cu. ft. air per gal.	No. of bacteria per c.c. 20° C.	No. of bacteria per c.c. 37° C.	Stability, in hours.	Suspended matter.	Parts per million, Nitrogen as Free ammonia	Parts per million, Nitrogen as Organic nitrogen.	Parts per million, Nitrogen as Nitrite	Parts per million, Nitrogen as Nitrate.	Oxygen: Oxygen consumed, p.p.m.	Oxygen: Dissolved oxygen, p.p.m.
Sewage effluent	Oct., 1915	Air 53° F.	62° 63°	59,000	1.6	1,384,000 56,000	347,000 12,000	... 120	263 16	17.0 5.1	38 9	0.21 0.22	0.10 8.70	127 19	1.5 2.8
Sewage effluent	Nov., 1915	Air 41° F.	59° 61°	60,000	2.1	1,242,000 119,000	297,000 12,000	... 120	438 16	17.5 11.4	40 17	0.16 1.09	0.20 4.10	149 27	2.3 6.3
Sewage effluent	Jan., 1916	Air 27° F.	50° 49°	71,000	1.7	770,000 62,000	170,000 8,800	... 88	336 11	15.4 14.7	35 19	0.13 0.16	0.51 0.67	135 31	5.5 6.1
Sewage effluent	Feb., 1916	Air 22° F.	51° 50°	68,000	2.1	960,000 68,000	150,000 8,000	... 96	300 14	17.2 16.5	42 22	0.16 0.17	0.36 0.50	143 27	4.8 6.4
Sewage effluent	Mar., 1916	Air 37° F.	50° 50°	71,000	2.3	1,000,000 159,000	126,000 16,000	... 67	383 15	15.8 15.2	36 21	0.13 0.19	0.41 0.42	146 35	4.7 6.0

As the oxidation of organic matter obtained with the activated sludge process depends upon the activity of living bacteria which do their best work at 68° to 70° F., we looked forward with some misgiving to the winter period when their vitality would be checked by the cold sewage.

But by increasing the volume of air applied the plants removed the suspended and colloided matter and bacteria in a satisfactory manner as indicated by the analysis given in Table I.

The data given in table I show that as the temperature of the sewage dropped the oxidation of the organic matter decreased as indicated, by the fact that nitrates in the effluent fell from 8.7 in October to 0.67 part per million in January and the oxygen consumed increased from 19 to 31.

The decrease in oxidation was accompanied by a decrease in stability of the effluent from 5 days to 3 days.

The treated liquor contained 6 p. p. m. of dissolved oxygen in January, February and March and only a trace of nitrate, whereas in summer nitrates are high and dissolved oxygen is low, therefore the liquor seems to depend for its stability upon nitrates in summer and dissolved oxygen in winter.

Briefly speaking, then, the data given in Table I show that at winter temperatures good bacterial removal and clarification can be maintained without oxidizing the ammoniacal nitrogen into nitrate.

Sludge Disposal.—Bearing in mind the fact that quantities of fat, nitrogen, and perhaps phosphoric acid are turned into the sewers daily by the households, breweries, packing houses, tanneries, etc., men interested in sewage treatment have maintained for years that quantities of material, valuable for fertilizer were being wasted by dumping the sewage of Milwaukee into Lake Michigan.

The great problem connected with the recovery of these products lies in separating the sludge from the water. The activated sludge for instance contains 98 per cent of water and 2 per cent of suspended solids. Moreover some of the solids seem to have a sticky nature. Heretofore when centrifuges or presses of the usual patterns were employed they proved to be unsatisfactory either because the cloths employed as strainers became choked with the gluey matters or else considerable quantities of lime had to be added to give enough body to the liquor for the presses to work upon. The lime added attacked the nitrogen compounds, driving off ammonia and combined with the fats to form insoluble soaps. Such treatment decreased the value of the sludge and by building up the volume increased the cost of removal.

The Henry R. Worthington Co. installed a new type of press at the Milwaukee Sewage Testing Station and it has treated the activated sludge with marked success. No lime is required, the bags do not get sticky, comparatively little power is used, and the sludge obtained can be converted into a fertilizer.

Typical analysis of activated sludge reaerated, and pressed sludge cake is given in Table II.

Some characteristic samples of the sludge sent to outside laboratories for analysis were found to contain about 0.43 per cent of potash.

From the data obtained at the Milwaukee Sewage Testing Station it appears that the activated sludge process will yield about 3,000 or 4,000 gal. of sludge containing 98 per cent of water per 1,000,000 gal. of sewage treated. When reduced to 10 per cent of moisture this sludge will weigh about ½ ton. Assuming that the nitrogen is worth $2 per unit, the value of the sludge should range between $10 and $12 a ton. We estimate that it will cost $5 to $6 to convert the sludge into fertilizer and pay freight to the consumer.

The data given in Table I show that the suspended matters in the Milwaukee sewage received at the station are

TABLE II.—AVERAGE ANALYSIS OF REAERATED ACTIVATED SLUDGE AND PRESS CAKE.

Source of sample.	Specific gravity.	Per cent of moisture.	Per cent by weight calculated to basis of 10% of moisture. Solids— Mineral.	Solids— Organic.	Fat.	Nitrogen as— Total calculated as free ammonia.	Nitrogen as— Free ammonia.	Nitrogen as— Albuminoid ammonia.	Nitrogen as— Nitrate.	Total phosphoric acid.
Sludge	1.004	98.9	32.5	57.3	5.8	5.6	1.17	3.19	0.30	2.3
Cake	1.113	74.6	30.2	59.9	4.3	6.3*	0.59	2.82	0.12	1.88

*Note.—These figures for nitrogen were obtained upon sludge which had been stored with continuous aeration for several days and are about 1 per cent higher than would be obtained by pressing fresh sludge.

---

[*] Paper before American Chemical Society, Urbana, Ill., April 18-21, 1916.

rather high, perhaps ⅓ to ½ greater than average American sewages carry. For that reason the volume of the sludge recovered here may be greater than would develop in cities where water is used more extravagantly.

Experiments upon the treatment of sewage by the activated sludge process in winter have therefore shown, first, that about 90 per cent of suspended matter and bacteria were removed, and second, that the sludge can be dried from 98 to 75 per cent, thereby converting it into a small volume which can be handled easily, and third, that the sludge has a sufficient market value to ensure a constant market.

A NEW NON-FREEZING EXPLOSIVE FOR GENERAL EXCAVATION.

Arctic is the name of a new brand of explosives which are truly non-freezing under the most severe winter conditions. They are quite water resisting but should not be used in submarine work. They can be used in driving tunnels, shafts or other close work as the fumes given off on detonation are not obnoxious, and will not cause headaches. They can be furnished in all standard size cartridges. If necessary, they can be packed in bulk, in paper bags which are in turn enclosed in wooden cases. To detonate them properly nothing less in strength than a No. 6 (Red Label) detonator may be used. Arctic is made in five different strengths which on a weight for weight basis are as follows:

Arctic No. 3 is equivalent in strength to a 60% dynamite.
Arctic No. 4 is equivalent in strength to a 45% dynamite.
Arctic No. 5 is equivalent in strength to a 40% dynamite.
Arctic No. 6 is equivalent in strength to a 30% dynamite.
Arctic No. 7 is equivalent in strength to a 25% dynamite.

Arctic powders can be used in quarry blasting, tunneling, shaft sinking, mining, subsoiling, tree planting, stump blasting, ditching by the electrical method, breaking up ice jams and in many other kinds of work. They contain no nitroglycerine and are therefore materially cheaper than straight or extra grades. Their velocity of detonation is even quicker than straight dynamites. The new explosive is made by the E. I. du Pont de Nemours & Co., Wilmington, Del.

PAVED HIGHWAYS AND NATIONAL DEFENSE.

By P. S. Bond, Major Corps of Engineers, U. S. A.

The usefulness in war of a substantial system of highways can scarcely be overstated, but it can be misunderstood and frequently is. Our freedom from wars, during long periods, has made the term "military road" little more than an historical phrase in America. It calls to mind the Cumberland pike and suggests the conditions of military enterprise that gave rise to our constitutional provision for federal military roads.

Those conditions antedate the railroad. In the present state of affairs the longer hauls for the assembling of soldiers, munitions and supplies will almost invariably be made by rail. Military considerations do not call for long single lines of road through the interior of the nation so much as for intensive systems of parallel and intersecting roads in the probable zones of actual warfare in case of attack by a foreign enemy.

To appreciate the tremendous usefulness of such road systems, it may be necessary to review some of the conditions of modern war as exemplified in Europe today. In speaking of innovations, I use the word with respect to popular American conceptions of war, which are still largely founded on the civil war of the sixties. The European war has really developed very few innovations, from the standpoint of the military student. Attacks by gas and liquid fire, effective as surprises, have been among these few. The general nature of the struggle was either anticipated by military men or actually demonstrated in the other wars of the last two decades. I wish particularly to refer to some phases of modern war with reference to the use of highways.

While less reliance than formerly is placed upon permanent fortifications, trench warfare between nearly equal forces tends to develop a condition of deadlock, in which the tactics are similar to those of a siege. Hence the routes of supply do not, under certain conditions, vary as much as in the old days of open fighting when one army would pursue another half across a continent on foot.

Not only are routes of distribution more nearly permanent, but the volume and weight of the traffic is such as to justify and require the most substantial kind of highways. Larger armies eat more food. Larger and more intricate guns consume immensely more ammunition. The British army in Belgium is said to have fired more shells in a single day than were used in the entire Boer war. These are transported from the railroad terminals to the place of consumption very largely by motor truck and the effect on any but the most substantial roads can be imagined.

Add to these conditions the mobility now required for very heavy guns. It can be seen that the placing and replacing of ordnance weighing many tons per piece—the saving of guns in case of a sudden retreat—would be virtually impossible under the conditions that prevail on most American highways during long seasons, or would impose the heaviest possible tasks upon the engineering arm of the service.

We have pictures showing the kind of improvised roads upon which the resourceful Germans have been compelled to rely in Russia. They follow the principles of the old American corduroy road, with a foundation of stringers and transverse logs, on which are laid brush and dirt. The contrasting advantages of level durable road surfaces, prepared in time of peace with an eye to the exigencies of war, are so striking as to make comment unnecessary.

But the greatest advantage of motor trucks and suitable motor roads has yet to be mentioned. To appreciate it, one must bear in mind the broad nature of battle tactics. War is not unlike football. An army must hold the foe in check at all points on the line and relies for its success upon smashing attacks by the concentration of troops at some particular point. In the old days the plan of attack was often concealed from the enemy until the moment when it was sprung. Distance and natural obstacles to vision made it possible to work out a maneuver with comparative leisure. Today the hostile aeroplane hovers overhead and conveys prompt information of the concentration of any considerable body of troops at any given quarter.

To render such an attack effective, it is therefore necessary to make it a sudden attack, like the dash of the backfield in a football game. To be able to move a whole division by truck and auto to a critical point at a rate of 20 or 30 miles an hour would greatly facilitate both offense and defense. It is said that the battle of the Marne was won by the sudden concentration of French troops, using motor transport over the splendid chaussees of France, upon the German left wing.

One road will not suffice for this variety of tactics, although one is better than none. The ideal would be a number of parallel routes traversing the line of battle, with frequent cross roads to permit the distribution of reinforcements at any desired point or points. In war, football or chess there is only one rule for success, and that is to oppose a lesser force with a greater force at the crucial point in the conflict. This does not mean that the largest army always wins, for the largest army may have three-quarters of its numbers out of action through lack of generalship or failure of transport facilities. Mobility can take the place of numbers much better than numbers can be made to take the place of mobility. When this fact is digested, the immense tactical value of paving can be better appreciated.

The motor can thus lessen the fatigue of forced marches and increase their possible radius five fold or more. It is also probable that motors will take over part of the work of transport formerly accomplished by rail. There is considerable necessary delay in entraining troops and getting a clear track for their movement, so much so that the old rule was to undertake movements of 30 miles or less on foot, as being prompter than train service. With suitable roads and an abundance of motor vehicles, this line of demarcation might be placed at 60 or 100 miles or more, depending on the particular circumstances of the case.

The unimproved highway is our weakest link today from the standpoint of military transport. America has the railroads. It has the autos and auto trucks. Whether the latter can be used, or whether we must go back to the age of the mule whacker and the dreary march rests with those who are responsible for our highway improvements. Any city within a hundred miles of our coast or frontier may some day be the base of military operations that will put its surrounding highways to the severest test. Very few would meet it creditably. Cuyahoga County, surrounding Cleveland, would offer a better opportunity for modern maneuvers than any similar locality with which I am familiar. The brick road, properly constructed, stands high in the estimation of army men for such purposes as I have been describing.

In a military crisis such a system of roads would much more than pay for itself in the saving of other forms of military expenditure. Considering also how they conduce to the wealth of the nation in times of peace, there seems to be no possible argument against this phase of preparedness.

EXPERIENCES IN THE APPLICATION OF THE ACTIVATED SLUDGE PROCESS TO CHICAGO STOCKYARDS SEWAGE.*

By Arthur Lederer, Chemist, Sanitary District of Chicago.

The Sanitary District of Chicago began experiments with the activated sludge process of sewage treatment on Stockyards and Packingtown sewage in April, 1915. The operation on the fill and draw plan was carried on in two galvanized iron tanks, each holding approximately 200 gal. of sewage. These experiments were continued well into the cold season, being discontinued when the contents of the tanks froze solid. Certain observations were made, which can be explained by the effect of low temperatures upon the process. These observations were substantiated on the larger 4 unit installation of the Sanitary District designed to treat from 30,000 to 100,000 gal. on the continuous flow basis daily. This installation was put into operation early in 1916 and is under the direction of Langdon Pearse.

The object of this article is to elaborate certain facts of a chemical and biologic nature which have presented themselves in the course of operation, and not to furnish any prescription for the treatment of the Stockyards waste. The operation features now being worked out will require much time and experience before a final recommendation can be made. Economically the continuous flow process is apparently preferable, but it has certain disadvantages which the fill and draw plan avoids. Experience from our experiments and from those of others will probably indicate the solution. As with other sewage treatment processes, so is this governed primarily by the composition of the waste handled. The process being largely of a biologic nature is greatly influenced by the temperature of the sewage. In this respect the Stockyards waste lends itself readily to the process, the temperature varying between 60° and 90° F. throughout the entire year. The loss in temperature in the plant is only a few degrees in the coldest winter weather. By far the greater percentage of the sewage treated is packinghouse waste. The variation in the day and night flow is extremely marked qualitatively and quantitively as well. The free oxygen demand is approximately 8 to 10 times greater than that of the domestic sewage in Chicago.

The changes of the nitrogenous constituents during the aeration process have been carefully studied. Our experience has coincided, so far as I am aware with the experience of other observers. During the warmer season a reduction of the free ammonia to about 1 or 2 p.p.m., and an increase of the nitrites to 5 or 10 p.p.m., indicates complete oxidation and clarification. This ceased to be the case, however, when colder weather set in with the small galvanized iron tanks, which were easily affected by changes in temperature in the air. Absolute stabilities were reached in cold days with the free ammonia actually increasing several hundred per cent, and with little, if any, change in the nitrites and nitrates. The reduction of the organic nitrogen was just as marked as in summer. Clarification was very satisfactory. The results I speak of are those noted when the effluent showed a relative stability of 100 or thereabouts. With the small galvanized iron tanks, in which the warm sewage quickly chilled, it took a considerably longer time in the cold weather to obtain such a high stability, but the chemical results were consistently as noted.

It is clear that in such cases the mechanical features of the process outweighed the biologic features. The highly putrescible colloids have simply been whipped out of suspension by the continuous agitation. Repeated observations indicate that the mere mechanical removal of the colloidal matter from sewage brings about an improvement far out of proportion to the actual percent of substance removed. There is no doubt, however, that there is some biologic activity even in a liquid near freezing, otherwise, we could hardly account for the persistent increase in free ammonia. We further noted various active protozoa, such as infusoria and trachelomonas in the sludge at all times. More highly developed animal or plant organisms were not found. Our work indicates that the temperature of the liquid treated will be a controlling factor. On a large scale temperature changes will probably be much lower than on the very small scale of 200-gal. steel tanks exposed to weather.

During the cold weather we had no ready chemical index to go by, although the regular routine tests of long duration were available. The removal of the colloidal matter was the only immediate indication of accomplished oxidation. This forced us to determine regularly the turbidity of the settled aerated sewage. Used with the methylene blue putrescibility test, a fairly definite working relation can be established. The tabulation of a large number of results obtained shows that the stability is 100 with turbidities of 10 p.p.m. or less. With a turbidity of 15 p.p.m., the relative stability varies usually between 50 and 100. With turbidities above 15, the quality of the effluent shows rapid deterioration. At turbidities ranging from 20 to 25 the stabilities are usually below 50. To compare turbidities above 25 p.p.m. with stabilities appears unsafe. Such stabilities are without exception very low. The relation spoken of is bound to vary with sewages of different character. Recently with the advent of warmer weather, the nitrites are again picking up in the effluent, and no doubt our ammonia index will again serve the purpose. The determination of other constituents, such as the organic nitrogen albuminoid ammonia, permanganate oxygen consumed, chlorine and the bacterial content are merely of scientific interest. They are not essential for a routine control. This holds good to a certain extent for the dissolved oxygen, but it is quite conceivable that the rate of de-oxygenation at a given temperature can be made to serve as an index of the degree of stabilization accomplished. The quantity of the settling suspended matter in the final effluent merely indicates the efficiency of the settling process, and has nothing to do with the activated sludge process proper. Packingtown sewage completely oxidized by the activated sludge process is clear with a slightly yellowish tint barely noticeable in small bulk.

---

*Paper read before American Chemical Society, Urbana, Ill., April 18-21, 1916.

No Danger of Timber Famine.—No one disputes the importance of conserving our forest resources. There is, however, no real danger of a timber famine. The United States government estimates that there is over 2,800 billion feet of standing timber which is slightly more than half of the original stand, the difference representing what has been utilized for general consumption, what has been cleared from agricultural lands and what has been destroyed by forest fires and waste.

DESIGN AND CONSTRUCTION OF THE FOUNDATION FOR THE UNION NATIONAL BANK BUILDING, CLEVELAND, O.*

The Union National Bank building, now nearing completion in Cleveland, O., presents some difficult problems in foundation design. This building, which is 17 stories high and has two basements, has a frontage of 45 ft. 4 in. on Euclid Ave. and extends 135 ft. on East Third St. Above the third floor an exterior court, 9 ft. wide by 79 ft. long, occupies the south half of the East Third St. side.

The entire first floor is given over to the main banking room, which, for architectural and practical reasons, was designed with a clear height of 40 ft. 0 in., and without interior columns. The interior columns above the first story are seated on heavy trusses placed in the banking room ceiling, and therefore practically the entire weight of the building above the second floor is carried to the foundations through the exterior columns, the center lines of which are about 1 ft. 9 in. from the building lines. The column loads on the east side of the building are greater than those on the west side, due partly to the exterior court on the west side, partly to the fact that the east wall (being on an interior lot line) had to be built as a blank wall, and partly to the fact that the large penthouse was on the east side.

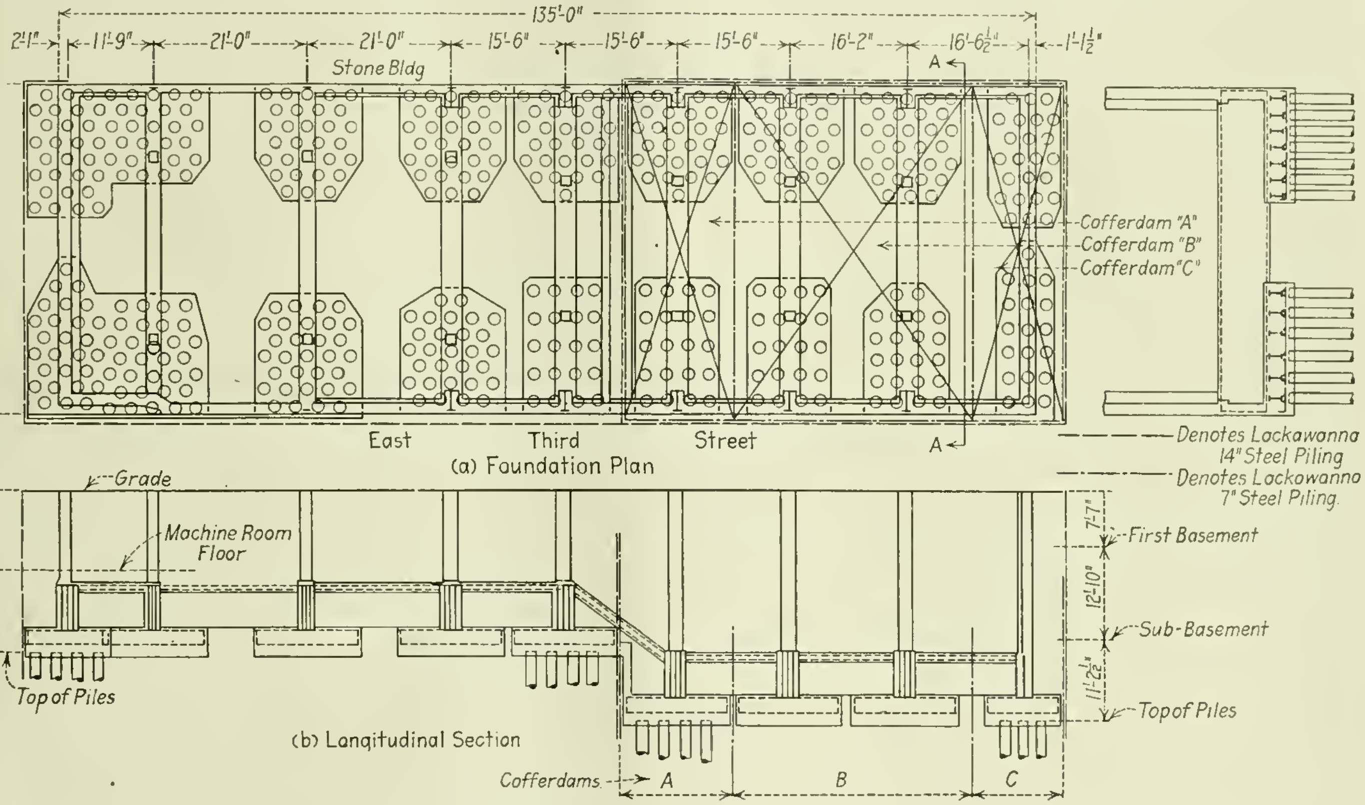


Fig. 1—Plan, Longitudinal Section and Cross Section of Foundation for Union National Bank Building, Cleveland, O.

Conditions Governing Foundation Design.—Apart from the distribution of the loads to be carried the following were important factors in the foundation design: the character of the subsoil; the desirability of carrying the foundation deep enough to insure safety in case deep foundations should be installed for an adjoining building on the east; and the desirability of providing for safety if subway excavations were ever made in front, in Euclid Ave.

Preliminary borings on the site revealed the typical strata of quicksand and hardpan which underlie the downtown section of Cleveland. It should be borne in mind, however, that the terms "quicksand" and "hardpan," as used in Cleveland, imply different materials from those ordinarily meant by these terms. The quicksand which underlies Cleveland is a coarser sand, and one not so thoroughly saturated with water as the true quicksand, and is therefore less treacherous and unmanageable. The hardpan in this case is a very stiff blue clay, somewhat moist. For a depth of about 20 ft. below grade the borings showed alternate layers of sand and gravel. At 23 ft. below grade—about the top of the piles in the upper basement level—ground water was encountered. Below this level, for a distance of about 20 ft., there were several strata composed largely of the so-called quicksand and hardpan.

Adjoining the building site on the east is the Stone building, a wall-bearing structure of three stories and basement. Across the alley in the rear stands a four-story building; and across East Third St., which is very narrow, there is a new six-story building (see Fig. 1a).

Design of Foundation.—A reinforced concrete mat over the entire building area was first considered, as the weight of the building and the allowable bearing required that the entire lot area be utilized. The non-uniformity of the column spacing in a north-and-south direction, however, rendered the problem of securing adequate reinforcement an indeterminate one (see Fig. 1a); and further complications were introduced by the fact that the column loads on the east side of the building are much greater than those on the west side. For these reasons it would have been impossible to distribute the loads uniformly over the building site, as the center of gravity of the loads would not have coincided with the center of gravity of the mat. This plan was therefore abandoned.

Further investigations indicated that the use of concrete piles, in groups, offered the most satisfactory solution of the problem. The center of gravity of each group of piles, however, could not be brought closer than a certain distance to the point of application of the column load, this distance being determined by the minimum allowable spacing for the driving of piles. The proper solution of the problem therefore consisted in spanning the distance between opposite columns with concrete or steel girders, bearing on the pile caps, and carrying the columns at their ends. Steel girders were chosen in preference to concrete girders, not because of the difficulty of designing the latter of sufficient strength, but because adequate connections between the steel columns and the concrete could not be made.

In this structure the effect of wind is comparatively small in a north-and-south direction, as the building has a length of 135 ft. In an east-and-west direction, however, the structure is only 45 ft. 4 in. wide, and the effect of the wind would be to set up slight vibrations at the points of anchorage of the steel columns to the concrete, which in time would weaken the connections.

---

*Based on article by R. B. Buettell in the Wisconsin Engineer.

In the design adopted the effect of vibrations due to the wind was largely overcome by riveting a thick plate to the outside of the lower end of the column and extending this plate, for the entire depth of the girder, at its end. The girders were secured at each end to I-beam grillages embedded in the pile caps. Each girder was designed for the maximum bending moment caused by column loads at its ends and the reactions assumed to act at the center of gravity of the pile groups. Figure 1 (a) shows a plan, Fig. 1 (b) a longitudinal section, and Fig. 1 (c) a cross section of the foundation. The interior columns, designated by letters in the plan of Fig. 1 (a), do not extend above the banking room floor, and therefore do not carry heavy loads.

Construction Features.—In constructing the foundation special precautions were taken to insure the safety of adjacent buildings. As the excavation, especially in the deep section at the south end of the building, had to be carried to a much lower level than the foundations of the adjacent buildings it was necessary to prevent the movements of earth from beneath these foundations. To accomplish this, after the old building which occupied the site had been wrecked, 14-in. Lackawanna steel sheet piling was driven along three sides of the site, as shown on the plan of Fig. 1, and the excavation was then carried to the level of the bottoms of the concrete pile caps in the north or upper section of the building. This sheet piling was braced across the entire width of the lot by heavy timbers held by jacks against horizontal waling pieces, on the East Third St. side, and butting directly against vertical waling pieces on the wall of the Stone building. The object of providing vertical rather than horizontal waling pieces against the wall of the Stone building was to facilitate the moving of each heavy timber independently, in order that the piledriver (which was mounted on top of the bracing), could operate with sufficient clearance between the timbers.

After the heavy piling had been driven a line of 7-in. Lackawanna piling was driven across the site, between the deep section and the shallow one (see Fig. 1a), and excavation was started in the deep section. At the same time a trench was dug along the wall of the Stone building, and this wall was carefully underpinned and carried down to the required levels below the new work. After the underpinning was completed 7-in. piling was driven along that part of the Stone building wall adjoining the deep section.

As the excavating proceeded in the deep section 7-in. piling was driven to form three cofferdams, as shown in Figs. 1 a and 1 b. The reasons for installing these cofferdams were: First, to provide additional protection against the possible failure of the steam and water mains in East Third St., which might be caused by the continual jarring of the earth during the driving of the piles; second, to localize possible trouble due to the failure of the heavy piling; and third, more certainly to prevent the seepage of water and sand into the excavation, as the lighter piling was considered more nearly watertight than the heavy section, it having been driven under more favorable circumstances.

In cofferdam B (see Fig. 1a) a sump-pit was provided by driving 7-in. piling in a circle of the smallest possible diameter, and a centrifugal pump was placed in it. The purpose of this pit was to lower, as much as possible, the ground-water level, and thus facilitate the excavation. The bottom of the piling was kept 1 ft. above the top of the hardpan, in order that the water might enter the pit at the lowest possible level, and not seep in through the piling.

The work in the deep section was thus carried on in three units, and, after the concrete piles had been driven and the pile caps placed, the light steel piling was pulled and the concrete basement walls run up to grade. Raymond concrete piles were used, each pile being reinforced with six $\frac{5}{8}$-in. rods. The plan involving the use of cofferdams proved to be entirely satisfactory, as practically no water, and no sand at all, entered the excavation.

Personnel.—The building was designed by Walker and Weeks, architects, of Cleveland, whose engineer, T. J. Bryson, furnished the data on the design. The general contractor is the Crowell-Lundoff-Little Co., of Cleveland.

METHOD AND COST OF CONSTRUCTING CONCRETE SERVICE TEST ROAD AT PHILADELPHIA, PA.*

By William H. Connell, Chief of Bureau of Highways, Philadelphia, Pa.

The comparative quality of pavements, whether for city streets or country roads, can be determined only through service tests under similar traffic and climatic conditions. Also when different theories exist relative to the proper materials to employ or methods of construction to follow with respect to certain types of pavements such as concrete, actual service tests under similar conditions form the only true criteria, so that a service test roadway consisting of different sections constructed according to the latest theories of the experts on this subject is necessarily an invaluable guide in concrete road construction. With this object in view, it was decided to build a service test concrete roadway on Oxford Pike from the Northeast Boulevard to Rising Sun Ave., the length of which is 11,250 ft. or about 2.1 miles.

The construction was commenced on October 5, 1914, and continued until December 4, 1914, when, on account of cold weather, it was suspended until March 30, 1915. The concrete was completed on May 18, 1915, sixty-six working days being actually consumed on this work. The lateness of the season in which this work was done indicated that some of the work was not done under the most favorable conditions and is in a measure instrumental for some of the rather high costs. In all cases when the temperature was below freezing the road was covered with hay or canvas. The bituminous surfacing materials were applied between August 26, 1915, and September 14, 1915.

The total length was divided into five principal sections, each 2,250 ft. long and each being constructed of different materials and in varying proportions. These principal sections were further subdivided into two sections, one of which, 1,050 ft. long, was left uncovered, while the remaining 1,200-ft. section was treated with four different bituminous wearing surfaces, the length of each of these treatments being 300 ft. The bituminous materials employed for these wearing surfaces were Tarvia, Ugite, asphalt cut-back and Unionite.

Cross Section.—The cross section of the pavement was uniform throughout the entire length of the road, being 18 ft. in width and having a thickness of $7\frac{1}{4}$ in. at the center, $6\frac{1}{2}$ in. at the quarter points and 5 in. at the sides, the bottom being a flat plane. This section is the one generally recognized by experts as producing the best results, so that it was not considered necessary or advisable to experiment further with any other cross section.

Foundation.—The pavement was built on an old water-bound macadam roadway which varied from 9 to 18 in. in depth and which was first spiked and then scarified and the macadam removed to a depth of 5 in. below the finished grade, after which it was thoroughly rolled with a 10-ton roller.

Concrete Pavement.—The concrete used in the pavement was composed of 1 part cement, 2 parts fine aggregate and 3 parts coarse aggregate, varying in the different sections. The mixing was performed in a Ransome Concrete Mixer equipped with a charging device. The surface of the concrete was finished with a template out to the cross section of the road and then floated with wooden floats from a movable bridge built to span the concrete.

Joints.—Transverse joints were provided at intervals of 30 ft., and with the exception of ten joints which were laid at an angle of 30°, all were laid at right angles to the roadway. Two types of joints were used—prepared bituminous joints and steel protected joints.

---

*Advance sheets of annual report for the year 1915.

The prepared bituminous joints consisted of ¼-in. prepared felt which extended through the entire thickness of the concrete. In order to secure straight joints, especially on the grades and to facilitate the placing of the bituminous material, ¼-in. iron plates were placed across the road at each joint with the felt against it, and when the concrete was in place the joint was removed.

The steel protected joints consisted of plates 2½ in. in depth, ¼ in. thick which were installed with a Truss-Con holding device which was removed as soon as the concrete was placed, ¼ in. prepared felt extending through the entire thickness of the concrete was used between these plates.

Bituminous Surfaces: Tarvia.—After sweeping the surface of the concrete thoroughly, 1/5 gal. per square yard of Tarvia B was applied with a pressure distributor. After this had thoroughly dried, ¼ gal. per square yard of Tarvia A was applied with a pressure distributor at a temperature of 250°, and covered with a thin layer of ½-in. clean trap rock chips (10 lb. per square yard). Three days later a second coat of Tarvia A, ¼ gal. per square yard, was applied with a pressure distributor and covered with a thin layer of ½-in. trap rock chips (20 lb. per square yard).

Ugite.—After sweeping the surface of the concrete, 1/10 to ⅛ gal. per square yard of Ugite A was applied with a pressure distributor and after two hours covered with a thin layer of ½-in. clean trap rock chips (10 lb. per square yard). The following day, ⅓ to 3/10 gal. per square yard of Ugite No. 3 was applied at a temperature of 250° by a pressure distributor, which in turn was covered with a thin layer of ½-in. clean trap rock chips (20 lb. per square yard). The following day the second application of Ugite No. 3, of ⅓ to 3/10 gal. per square yard, was applied with a pressure distributor and covered with ½-in. trap rock chips (20 lb. per square yard). This application was rolled lightly with a five-ton roller.

Asphalt Cut-Back.—After sweeping the surface of the concrete thoroughly, a paint coat consisting of 50 per cent naphtha and 50 per cent of asphalt having a penetration of from 55 to 65 and in an amount of ⅛ gal. per square yard, was applied with a pressure distributor. Twenty-four hours later an application of ⅓ gal. per square yard of asphalt with a penetration of from 70 to 80 cut-back with from 35 to 40 per cent of naphtha was applied with a pressure distributor. After two hours this was covered with a layer of trap rock chips graded from ⅛ to ½ in. (25 lb. per square yard), and then thoroughly compacted with a five-ton roller.

Unionite.—After the concrete surface had been thoroughly cleaned, a paint coat consisting of equal parts of asphalt with a penetration of from 55 to 65, and naphtha, in an amount of ⅛ gal. per square yard was applied with a pressure distributor. On the following day Unionite wearing surface was spread and rolled with a ten-ton roller, the thickness of this course being from ¼ to ⅜ in. after rolling. The Unionite consisted of specially prepared rock asphalt, ¼ in. crushed stone and Unionite asphaltic cement in the proportions of 47½ per cent rock asphalt, 2½ per cent asphaltic cement and 50 per cent stone, previously coated with asphaltic cement.

TABLE I.—OXFORD PIKE SERVICE TEST ROAD SCHEDULE OF WAGES.

	Per day.
Superintendent	$ 4.50
Foreman	3.00
Carpenters	3.60
Roller engineers	4.25
Pavers (straight time men)	2.50
Pavers (straight time men)	3.00
Watchmen	1.50
Laborers	$1.60 to 1.75
Single teams	3.50
Double teams	5.50
Engineers	3.00
Engineers (union)	4.25
Roller (ten-ton), with engineer	15.00

Equipment:
1 10-ton roller.
1 20-cu. ft. Ransome mixer.
1 20-cu. ft. Foote mixer.
1 5-ton roller.
Crusher plant—Output daily, 50 tons.

TABLE II.—SECTION 1; STATION 0 + 00 to 22 + 50.

Composition of Concrete: 1 part cement, 2 parts sand, 3 parts gravel passing a 1½-in. ring and retained on a ¼-in. screen.

Expansion Joints: From Station 0 + 30 to 5 + 40 — steel protected joints; 5 + 40 to 22 + 50 — bituminous joints.

Treatment of Surface: From Station 0 + 00 to 10 + 50 — untreated; 10 + 50 to 13 + 50—Tarvia; 13 + 50 to 16 + 50 — Ugite; 16 + 50 to 19 + 50 — asphalt cut-back; 19 + 50 to 22 + 50 — Unionite.

Cost Per Square Yard.

	Per sq. yd.
Preparation of subgrade	$0.0878
Concrete pavement	1.0085
Shoulders	0.0323
	$1.1286
Bituminous top—Tarvia	0.1358
Bituminous top—Ugite	0.1444
Bituminous top—Asphalt cut-back	0.1783
Bituminous top—Unionite	0.2153
Preparation of subgrade, concrete pavement and bituminous top Tarvia	1.2321
Preparation of subgrade, concrete pavement and bituminous top Ugite	1.2407
Preparation of subgrade, concrete pavement and bituminous top asphalt cut-back	1.1726
Preparation of subgrade, concrete pavement and bituminous top Unionite	1.3116

Detailed Cost Per Square Yard.

Preparation of Subgrade:		
Scarifying	$ 38.10	$0.0085
Shaping	340.25	0.0756
Rolling	16.60	0.0037
4,500 sq. yd. @ $0.0878	$ 394.95	$0.0878

Concrete Pavement:		Per sq. yd.
Portland cement, 1,320 bbls. @ $1.60	$2,112.00	$0.4693
Jersey gravel, 474.9 tons @ $1.20	569.88	0.1266
Whole pebbles, 762.3 tons @ $1.20	914.76	0.2033
Forms, steel and wooden, depreciation	44.00	0.0098
Labor	84.87	0.0189
Joints:		
Bituminous, 59	42.67	0.0095
Steel protected, 17	51.85	0.0115
Superintendence	45.45	0.0101
Labor, concreting	368.22	0.0818
Covering with dirt	25.63	0.0057
Removing dirt	14.34	0.0032
Pipe line	17.50	0.0039
Sprinkling	5.58	0.0012
Overhead charges for this section alone	50.75	0.0113
Miscellaneous expenses, coal, salaries, etc.	190.60	0.0424
4,500 sq. yd. @ $1.0085	$4,538.10	$1.0085

Shoulders:
Labor: 2,000 sq. yd. @ $0.0323 .... $64.55

Actual time for laying concrete:
787 cu. yd., 8 days 4 hours, or an average of 93.6 cu. yd. per day.
4,500 sq. yd., 8 days 4 hours, or an average of 535 sq. yd. per day.
Highest daily average, 600 sq. yd.

Tarvia:		Per sq. yd.
Materials:		
Tarvia B, paint coat, 168 gal. @ $0.09	$ 15.12	$0.0251
Tarvia A, first coat, 168 gal. @ $0.085	14.28	0.0238
Trap rock chips, 3 tons @ $1.68	5.04	0.0084
Tarvia A, second coat, 210 gal. @ $0.085	17.85	0.0298
Trap rock chips, 6 tons @ $1.68	10.08	0.0168
Extra chips, 4.4 tons @ $1.68	7.39	0.0123
Labor:		
Hauling chips	3.72	0.0062
Sweeping concrete	2.00	0.0034
Spreading chips	6.00	0.0100
600 sq. yd. @ $0.1358	$ 81.48	$0.1358

Ugite:		Per sq. yd.
Materials:		
Ugite A, 80 gal. @ $0.09	$ 7.20	$0.0120
Trap rock chips, 3 tons @ $1.68	5.04	0.0084
Ugite No. 3, first application, 175 gal. @ $0.10	19.50	0.0324
Trap rock chips, 6 tons @ $1.68	10 08	0.0168
Ugite No. 3, second application, 210 gal. @ $0.10	21.00	0.0350
Trap rock chips, 6 tons @ $1.68	10.08	0.0168
Labor:		
Hauling chips	3.72	0.0062
Sweeping concrete	1.00	0.0017
Spreading chips	7.05	0.0118
Rolling	2.00	0.0034
600 sq. yd. @ $0.1444	$ 86.67	$0 1444

Asphalt Cut-Back:		Per sq. yd.
Materials:		
Paint coat, 78 gal. @ $0.10	$ 7.80	$0.0130
Second coat, 170 gal. @ $0.10	17.00	0.0282
Trap rock chips, 8 tons @ $1.68	13.44	0.0224
Labor:		
Hauling chips	3.72	0.0062
Sweeping concrete	2.00	0.0034
Spreading chips	2.00	0.0034
Rolling	1.00	0.0017
600 sq. yd. @ $0.0783	$ 46.96	$0.0783

Unionite:		Per sq. yd.
Materials:		
Paint coat, 78 gal. $0.10	$ 7.80	$0.0130
Rock asphalt, 3.6 tons @ $15.00	54.00	0.0900
Trap rock chips, 3.8 tons @ $2.00	7.60	0.0127
Asphaltic cement, 550 lb. @ $0.01	5.50	0.0092
Labor:		
Cleaning concrete	13.20	0.0219
Hauling material	9.90	0.0165
Rolling	1 80	0.0030
Erecting temporary plant	6.00	0.0100
Labor	23.40	0.0390
600 sq. yd. @ $0.2153	$ 129.20	$0.2153

TABLE III.—SECTION 2: FROM STATION 22 + 50 to 45 + 00.

Composition of Concrete: 1 part cement, 2 parts sand, 3 parts trap rock, passing a 1½-in. ring and retained on a ¼-in. screen.

Subgrade: A corduroy road formerly existed from Station 37 + 20 to 37 + 60, on account of the "springy" condition of the soil, and a considerable amount of stone was placed on the subgrade at this point and well rolled.

Expansion Joints: From Station 34 + 80 to 39 + 90—steel protected joints: 22 + 50 to 34 + 80 and 39 + 90 to 43 + 50—bituminous joints; 43 + 50 to 45 + 00—5 steel protected joints at an angle of 30 degrees to the center line.

Treatment of Surface: From Station 22 + 50 to 25 + 50—Tarvia; 25 + 50 to 28 + 50—Ugite; 28 + 50 to 31 + 50—asphalt cut-back; 31 + 50 to 34 + 50—Unionite; 34 + 50 to 45 + 00—untreated.

Cost Per Square Yard.

	Per sq. yd.
Preparation of subgrade	$0.1123
Concrete pavement	1.1408
Shoulders	0.0237
	$1.2768
Bituminous top—Tarvia	0.1344
Bituminous top—Ugite	0.1444
Bituminous top—Asphalt cut-back	0.0783
Bituminous top—Unionite	0.2153
Preparation of subgrade, concrete pavement and bituminous top—Tarvia	1.3875
Preparation of subgrade, concrete pavement and bituminous top—Ugite	1.3975
Preparation of subgrade, concrete pavement and bituminous top—Asphalt cut-back	1.3314
Preparation of subgrade, concrete pavement and bituminous top—Unionite	1.4684

Detailed Cost Per Square Yard.

Preparation of Subgrade:		
Scarifying	$ 44.80	$0.0100
Shaping	437.59	0.0972
Rolling	23.00	0.0051
4,500 sq. yd. @ $0.1123	$ 505.39	$0.1123

		Per sq. yd.
Concrete Pavement:		
Portland cement, 1,372 bbls. @ $1.60	$2,195.20	$0.4878
Jersey gravel, 516.2 tons @ $1.20	619.44	0.1376
Trap rock { 500 tons @ $1.55	775.47 }	0.2836
{ 291.2 tons @ $1.72	500.86 }	
Forms, steel and wooden, depreciation	44.00	0.0098
Labor	103.19	0.0229
Joints:		
Bituminous, 53	38.29	0.0085
Steel, 22	44.04	0.0098
Superintendence	63.00	0.0140
Labor, concreting	413.70	0.0919
Covering with dirt	20.18	0.0045
Removing dirt	19.48	0.0043
Pipe line	34.58	0.0077
Sprinkling	6.86	0.0015
Overhead charges for this section alone	65.47	0.0145
Miscellaneous expenses, salaries, coal, etc	190.60	0.0424
1,500 sq. yd. @ $1.1408	$5,133.86	$1.1408

Shoulders:

Labor: 2,000 sq. yd. @ $0.0237....$47.35

Actual time for laying concrete in Section No. 2:

787 cu. yd., 8 days 3½ hours, or an average of 94.33 cu. yd. per day.

4,500 cu. yd., 8 days, 3½ hours, or an average of 539 sq. yd. per day.

Highest daily yardage, 600 sq. yd.

		Per sq. yd.
Tarvia:		
Materials:		
Tarvia B, paint coat, 168 gal. @ $0.09	$ 15.12	$0.0251
Tarvia A, first coat, 168 gal. at $0.085	14.28	0.0238
Trap rock chips, 3 tons @ $1.68	5.04	0.0084
Tarvia A, second coat, 210 gal. @ $0.085	17.85	0.0298
Trap rock chips, 6 tons @ $1.68	10.08	0.0168
Extra chips, 3.9 tons @ $1.68	6.55	0.0109
Labor:		
Hauling chips	3.72	0.0062
Sweeping concrete	2.00	0.0034
Spreading chips	6.00	0.0100
600 sq. yd. @ $0.1344	$ 80.64	$0.1344

		Per sq. yd.
Ugite.		
Materials:		
Ugite A, 80 gal. @ $0.09	$ 7.20	$0.0120
Trap rock chips, 3 tons @ $1.68	5.04	0.0084
Ugite No. 3, first application, 195 gal. @ $0.10	19.50	0.0324
Trap rock chips, 6 tons @ $1.68	10.08	0.0168
Ugite No. 3, second application, 210 gal. @ $0.10	21.00	0.0350
Trap rock chips, 6 tons @ $1.68	10.08	0.0168
Labor:		
Hauling chips	3.72	0.0062
Cleaning concrete	1.00	0.0012
Spreading chips	7.05	0.0118
Rolling	2.00	0.0034
600 sq. yd. @ $0.1444	$ 86.67	$0.1444

		Per sq. yd.
Asphalt Cut-Back:		
Materials:		
Paint coat, 78 gal. @ $0.10	$ 7.80	$0.0130
Second coat, 170 gal. @ $0.10	17.00	0.0282
Trap rock chips, 8 tons @ $1.68	13.44	0.0224
Labor:		
Hauling chips	3.72	0.0062
Sweeping concrete	2.00	0.0034
Spreading chips	2.00	0.0034
Rolling	1.00	0.0017
600 sq. yd. @ $0.0783	$ 46.96	$0.0783

		Per sq. yd.
Unionite:		
Materials:		
Paint coat, 78 gal. @ $0.10	$ 7.80	$0.0130
Rock asphalt, 3.6 tons @ $15	54.00	0.0900
Trap rock chips, 3.8 tons @ $2	7.60	0.0127
Asphaltic cement, 550 lb. @ $0.01	5.50	0.0092
Labor:		
Cleaning concrete	13.20	0.0219
Hauling material	9.90	0.0165
Rolling	1.80	0.0030
Erecting temporary plant	6.00	0.0100
Labor	23.40	0.0390
600 sq. yd. @ $0.2153	$ 129.20	$0.2153

TABLE IV.—SECTION 3: FROM STATION 45 + 00 to 67 + 00.

Composition of Concrete: 1 part Portland cement; 2 parts trap rock grit; 3 parts trap rock, passing a 1½-in. ring and retained on a ¼-in. screen.

From Station 53 + 10 to 67 + 50 a mixture of fine and coarse grit was used in the proportions of one-half coarse and one-half fine. In the remainder of the section regular trap rock screenings were used.

Joints: From Station 45 + 60 to 50 + 10—steel protected joints; 50 + 10 to 67 + 10—bituminous joints.

Treatment of Surface: From Station 45 + 00 to 55 + 50—untreated; 55 + 50 to 58 + 50—Tarvia; 58 + 50 to 61 + 50—Ugite; 61 + 50 to 64 + 50—asphalt cut-back; 64 + 50 to 67 + 50—Unionite.

Cost Per Square Yard.

	Per sq. yd.
Preparation of subgrade	$0.0875
Concrete pavement	1.2061
Shoulders	0.0408
	$1.3344
Bituminous top—Tarvia	$0.1344
Bituminous top—Ugite	0.1444
Bituminous top—Asphalt cut-back	0.0783
Bituminous top—Unionite	0.2153
Preparation of subgrade, concrete pavement and bituminous top—Tarvia	1.4280
Preparation of subgrade, concrete pavement and bituminous top—Ugite	1.4380
Preparation of subgrade, concrete pavement and bituminous top—Asphalt cut-back	1.3719
Preparation of subgrade, concrete pavement and bituminous top—Unionite	1.5089

Detailed Cost Per Square Yard.

Preparation of Subgrade:		
Scarifying	$ 22.25	$0.0051
Shaping	344.23	0.0786
Rolling	16.85	0.0038
	$ 383.33	$0.0875

		Per sq. yd.
Concrete Pavement:		
Portland cement, 1,277 bbl. @ $1.60	$2,043.20	$0.4665
Trap rock grit { 83.5 tons @ $2	167.00 }	0.2035
{ 425.9 tons @ $1.70	744.03 }	
Trap rock { 643.9 tons @ $1.72	1,107.51 }	0.2737
{ 57 tons @ $1.60	91.20 }	
Forms—Steel and wooden, depreciation	44.00	0.0100
Labor	114.40	0.0261
Joints—		
Bituminous, 57	42.53	0.0097
Steel, 15	44.80	0.0102
Superintendence	72.00	0.0164
Labor, concreting	411.90	0.0941
Covering with dirt	23.10	0.0052
Removing dirt	8.90	0.0021
Pipe line	61.25	0.0140
Sprinkling	3.75	0.0008
Overhead charges for this section alone	32.79	0.0303
Miscellaneous expenses, salaries, coal, etc	190.60	0.0435
4,380 sq. yd. @ $1.2061	$5,282.96	$1.2061

Shoulders:

Labor: 2,000 sq. yd. @ $0.0480....$81.63

Actual time for laying concrete:

767 cu. yd., 7 days 8 hours, or an average of 98.25 cu. yd. per day

4,380 sq. yd., 7 days 8 hours, or an average of 561.5 sq. yd. per day.

Highest daily yardage, 660 sq. yd.

		Per sq. yd.
Tarvia:		
Materials:		
Tarvia B, paint coat, 168 gal. @ $0.09	$ 15.12	$0.0251
Tarvia A, first coat, 168 gal. @ $0.085	14.28	0.0238
Trap rock chips, 3 tons @ $1.68	5.04	0.0084
Tarvia A, second coat, 210 gal. @ $0.085	17.85	0.0298
Trap rock chips, 6 tons @ $1.68	10.03	0.0168
Extra chips, 3.9 tons @ $1.68	6.55	0.0109
Labor:		
Hauling chips	3.72	0.0062
Sweeping concrete	2.00	0.0034
Spreading chips	6.00	0.0100
600 sq. yd. @ $0.1344	$ 80.84	$0.1344

		Per sq. yd.
Ugite:		
Materials:		
Ugite A, 80 gal. @ $0.09	$ 7.20	$0.0120
Trap rock chips, 3 tons @ $1.68	5.04	0.0084
Ugite No. 3, first application, 195 gal. @ $0.10	19.50	0.0324
Trap rock chips, 6 tons @ $1.68	10.08	0.0168
Ugite No. 3, second application, 210 gal. @ $0.10	21.00	0.0350
Trap rock chips, 6 tons @ $1.68	10.08	0.0168
Labor:		
Hauling chips	3.72	0.0062
Cleaning concrete	1.00	0.0017
Spreading chips	7.05	0.0118
Rolling	2.00	0.0034
600 sq. yd. @ $0.1444	$ 86.67	$0.1444

		Per sq. yd.
Asphalt Cut-Back:		
Materials:		
Paint coat, 78 gal. @ $0.10	$ 7.80	$0.0130
Second coat, 170 gal. @ $0.10	17.00	0.0282
Trap rock chips, 8 tons @ $1.68	13.44	0.0224
Labor:		
Hauling chips	3.72	0.0062
Sweeping concrete	2.00	0.0034
Spreading chips	2.00	0.0034
Rolling	1.00	0.0017
600 sq. yd. @ $0.0783	$ 46.96	$0.0783

		Per sq. yd.
Unionite:		
Materials:		
Paint coat, 78 gal. @ $0.10	$ 7.80	$0.0130
Rock asphalt, 3.6 tons @ $15	54.00	0.0900
Trap rock chips, 3.8 tons @ $2	7.60	0.0127
Asphaltic cement, 550 lb. @ $0.01	5.50	0.0092
Labor:		
Cleaning concrete	13.20	0.0219
Hauling material	9.90	0.0165
Rolling	1.80	0.0030
Erecting temporary plant	6.00	0.0100
Labor	23.40	0.0390
600 sq. yd. @ $0.2153	$ 129.20	$0.2153

TABLE V.—SECTION 4: FROM STATION 67 + 50 to 90 + 00.

Composition of Concrete: 1 part Portland cement; 2 parts trap rock grit; 3 parts limestone, passing a 1½-in. ring and retained on a ¼-in. screen. In this section the mixture varies from 1:2:3 to 1:2½:2½ and 1:2⅓:2⅔, these two latter mixtures being used when the trap rock grit was oversize, i. e., the proportion of stone was reduced and the oversize grit considered coarse aggregate.

Joints: From Station 80 + 10 to 84 + 60—steel protected joints. The last two of these joints were placed at an angle of 30 degrees with the center line of the road. From Station 67 + 50 to 80 + 10—bituminous joints; 84 + 60 to 90 + 00—bituminous joints.

Treatment of Surface: From Station 67 + 50 to 70 + 50—Tarvia; 70 + 50 to 73 + 50—Ugite; 73 + 50 to 76 + 50—asphalt cut-back; 76 + 50 to 79 + 50—Unionite; 79 + 50 to 90 + 00—untreated.

Cost Per Square Yard.

	Per sq. yd.
Preparation of subgrade	$0.0739
Concrete pavement	1.2058
Shoulders	0.0597
	$1,3394
Bituminous top—Tarvia	0.1344
Bituminous top—Ugite	0.1361
Bituminous top—asphalt cut-back	0.0783
Bituminous top—Unionite	0.2153
Preparation of subgrade, concrete pavement and bituminous top—Tarvia	1.4141
Preparation of subgrade, concrete pavement and bituminous top—Ugite	1.4158
Preparation of subgrade, concrete pavement and bituminous top—asphalt cut-back	1.3580
Preparation of subgrade, concrete pavement and bituminous top—Unionite	1,4953

Detailed Cost Per Square Yard.

Preparation of Subgrade:		
Scarifying	$ 11.98	$0.0026
Shaping	306.15	0.0680
Rolling	14.85	0.0033
1,500 sq. yd. @ $0.0739	$ 332.98	$0.0739
		Per sq. yd.
Concrete Pavement:		
Portland cement 324 bbl. @ $1.68	$ 554.32	$0.5014
1,070 bbl. @ $1.60	1,712.00	
Trap rock grit 609.2 tons @ $1.70, fine	1,035.64	0.2367
15.1 tons @ $2, coarse	30.20	
Limestone, 629 tons @ $1.35	849.15	0.1887
Forms—Steel and wooden, depreciation	44.00	0.0098
Labor	125.41	0.0278
Joints—		
Bituminous, 59	47.61	0.0106
Steel, 16	48.24	0.0107
Superintendence	90.00	0.0200
Labor, concreting	447.98	0.0996
Covering with dirt	35.43	0.0079
Removing dirt	7.03	0.0016
Pipe line	32.18	0.0072
Sprinkling	3.16	0.0007
Overhead charges for this section alone	182.90	0.0407
Miscellaneous expenses, coal, salaries, etc	190.60	0.0424
4,500 sq. yd. @ $1.2058	$5,425.85	$1.2058
Shoulders:		
Labor: 2,000 sq. yd. @ $0.0597		$119.36

Actual time for laying concrete:
787 cu. yd., 9 days 1 hour, or an average of 865 cu. yd. per day.
4,500 sq. yd., 9 days, 1 hour, or an average of 494.5 sq. yd. per day.
Highest daily yardage, 600 sq. yd.

		Per sq. yd.
Tarvia:		
Materials:		
Tarvia B, paint coat, 168 gal. @ $0.09	$ 15.12	$0.0251
Tarvia A, first coat 168 gal. @ $0.85	14.28	0.0238
Trap rock chips, 3 tons @ $1.68	5.04	0.0084
Tarvia A, second coat, 210 gals @ $0.085	17.85	0.0298
Trap rock chips, 6 tons @ $1.68	10.08	0.0168
Extra chips, 3.9 tons @ $1.68	6.55	0.0109
Labor:		
Hauling chips	3.72	0.0062
Sweeping concrete	2.00	0.0034
Spreading chips	6.00	0.0100
600 sq. yd. @ $0.1344	$ 80.64	$0.1344
		Per sq. yd.
Ugite:		
Materials:		
Ugite A, 80 gal. @ $0.09	$ 7.20	$0.0120
Trap rock chips, 3 tons @ $1.68	5.04	0.0084
Ugite No. 3, 195 gal. @ $0.10	19.50	0.0324
Trap rock chips, 6 tons @ $1.68	10.08	9 0168
Ugite No. 3, 160 gal. @ $0.10	16.00	0.0266
Trap rock chips, 6 tons @ $1.68	10.08	0.0168
Labor:		
Hauling chips	3.71	0.0062
Cleaning concrete	1.00	0.0017
Spreading chips	7.05	0.0118
Rolling	2.00	0.0034
600 sq. yd. @ $0.1361	$ 81.66	$0.1361
		Per sq. yd.
Asphalt Cut-Back:		
Materials:		
Paint coat, 78 gal. @ $0.10	$ 7.80	$0.0130
Second coat, 170 gal. @ $0 10	17.00	0.0282
Trap rock chips, 8 tons @ $1.68	13.44	0.0224
Labor.		
Hauling chips	3.72	0.0062
Sweeping concrete	2.00	0.0034
Spreading chips	2.00	0.0034
Rolling	1.00	0.0017
600 sq yd. @ $0.0783	$ 46.96	$0.0783
		Per sq. yd.
Unionite:		
Materials:		
Paint coat, 78 gal. @ $0.10	$ 7.80	$0.0130
Rock asphalt, 3.6 tons @ $15	54.00	0.0900
Trap rock chips, 3.8 tons @ $2	7.60	0.0127
Asphaltic cement, 550 lb. @ $0.01	5.50	0.0092
Labor:		
Cleaning concrete	13.20	0.0219
Hauling material	9.90	0.0160
Rolling	1.80	0.0030
Erecting temporary plant	6.00	0.0100
Labor	23.40	0.0390
600 sq. yd. @ $0.2153	$ 129.20	$0.2153

TABLE VI—SECTION 5.—FROM STATION 90+00 TO 112+50.

Composition of Concrete: 1 part Portland cement; 1 part sand; 1 part trap rock grit; 3 parts trap rock, passing a 1½-in. ring and retained on a ¼-in. screen.

Joints: From Station 90 + 60 to 96 + 50 steel protected joints; from station 90 + 00 to 96 + 30—bituminous; from station 96 + 30 to 112 + 50—bituminous.

Treatment of Surface: From station 90 + 00 to 100 + 50—untreated; from station 100 + 50 to 103 + 50—Tarvia; from station 103 + 50 to 106 + 50—Ugite; from station 196 + 50 to 109 + 50—asphalt cut-back; from station 100 + 50 to 112 + 50—Unionite.

Cost Per Square Yard.

	Per Sq. Yd.
Preparation of subgrade	$0.0170
Concrete pavement	1.2566
Shoulders	0.0509
	$1.4145
Bituminous top—Tarvia	0.1344
Bituminous top—Ugite	0.1319
Bituminous top—Asphalt cut-back	0.0783
Bituminous top—Unionite	0.2153
Preparation of subgrade, concrete pavement and bituminous top—Tarvia	1.4880
Preparation of subgrade, concrete pavement and bituminous top—Ugite	1.4955
Preparation of subgrade, concrete pavement and bituminous top—Asphalt cut-back	1.4419
Preparation of subgrade, concrete pavement and bituminous top—Unionite	1.5789

Detailed Cost Per Square Yard.

Preparation of Subgrade:		
Scarifying	$ 21.75	$0.0046
Shaping	467.23	0.0984
Rolling	19.13	0.0040
4,750 sq. yd. @ $0.1070	$508.13	$0.1070
Concrete Pavement:		
Portland cement 1,321.0 bbl. @ $1.60	$2,113.60	$0.4957
142.0 bbl. @ $1.68	238.56	
Jersey gravel 248.4 tons @ $1.20	298.08	0.0696
25.8 tons @ $1.25	32.25	
Trap rock grit 101.8 tons @ $2.00, coarse	203.60	0.1158
203.5 tons @ $1.79, fine	345.95	
Trap rock 285.5 tons @ $1.72	491.06	0.2835
173.5 tons @ $1.55	733.93	
75.5 tons @ $1.60	120.80	
Forms—Steel and wooden, depreciation	44.00	0.0098
Labor	131.51	0.0277
Joints—		
Bituminous, 58	52.71	0.0111
Steel, 19	61.49	0.0129
Superintendance	77.40	0.0164
Labor, concreting	504.41	0.1062
Covering with dirt	22.58	0.0048
Removing dirt	12.57	0.0026
Pipe line	40.50	0.0085
Overhead charges for this section alone	239.94	0.0506
Miscellaneous expenses, coal, salaries, etc	190.60	0.0404
4,746.12 sq. yd. @ $1.2566	$5,965.51	$1.2566
Shoulders:		
Labor: 2,050 sq. yd. @ $0.0509	$0.0509	$ 104.35

Actual time for laying concrete:
830.27 cu. yd., 9 days 8 hours, or an average of 84.75 cu. yd. per day.
4,246.12 sq. yd., 9 days 8 hours, or an average of 484.3 sq.yd.per day.

Highest yardage, 600 sq. yd.

		Per sq. yd.
Tarvia:		
Materials:		
Tarvia B, paint coat, 160 gal. @ $0.09	$ 15.13	$0.0251
Tarvia A, first coat, 168 gal. @ $0.085	14.28	0.0238
Trap rock chips, 3 tons @ $1.68	5.04	0.0084
Tarvia A, second coat, 210 gal. @ $0.085	17.85	0.0293
Trap rock chips, 6 tons @ $1.68	10.08	0.0168
Extra chips, 3.9 tons @ $1.68	6.55	0.0109
Labor:		
Hauling chips	3.72	0.0062
Sweeping concrete	2.00	0.0024
Spreading chips	6.00	0.0100
600 sq. yd. @ $0.1344	$ 80.64	$0.1344
		Per sq. yd.
Ugite:		
Materials:		
Ugite A, 80 gal. @ $0.09	$ 7.20	$0.0120
Trap rock chips, 3 tons @ $1.63	5.04	0.0084
Ugite No. 3, 170 gal. @ $0.10	17.00	0.0282
Trap rock chips, 6 tons @ $1.68	10.03	0.0168
Ugite No. 3, 160 gal. @ $0.10	16.00	0.0266
Trap rock chips, 6 tons @ $1.68	10.08	0.0168
Labor:		
Hauling chips	3.71	0.0062
Cleaning concrete	1.00	0.0017
Spreading chips	7.05	0.0118
Rolling	2.00	0.0034
600 sq. yd. @ $0.1319	$ 79.16	$0.1319
		Per sq. yd.
Asphalt Cut-Back:		
Materials:		
Paint coat, 78 gal. @ $0.10	$ 7.30	$0.0130
Second coat, 170 gal. @ $0.10	17.00	0.0282
Trap rock chips, 8 tons @ $1.68	13.44	0.0221
Labor:		
Hauling chips	3.72	0.0062
Sweeping concrete	2.00	0 0034
Spreading chips	2.00	0.0034
Rolling	1.00	0.0017
600 sq. yd. @ $0.0783	$ 46.96	$0.0783
		Per sq. yd.
Unionite:		
Materials:		
Paint coat, 78 gal. @ $0.10	$ 7.80	$0.0130
Rock asphalt, 3.6 tons @ $15.00	54.00	0.0900
Trap rock chips, 3.8 tons @ $2.00	7.60	0.0127
Asphaltic cement, 550 lb. @ $0.01	5.50	0.0092
Labor:		
Cleaning concrete	12.30	0.0219
Hauling material	9.90	0.0165
Rolling	1.80	0.0030
Erecting temporary plant	6.00	0.0100
Labor	23.40	0.0390
600 sq. yd. @ $0.2153	$ 129.20	$0.2153

Milwaukee Sued for Typhoid Deaths.—As a result of the Milwaukee typhoid epidemic damage suits were brought against the city by some who had lost relatives by typhoid fever. The complainants made similar allegations to the effect that the disease was contracted from the use of lake water alleged to be sewage contaminated. Negligence was charged in that the city allowed the water to become contaminated and at the same time supplying it to citizens for drinking purposes. The complainants also charge that at various times during the last ten years the city officials have been notified of the condition of the water.

TESTS OF EFFECT OF METHOD OF BEDDING UPON THE SUPPORTING STRENGTH OF DRAIN TILE AND SEWER PIPE.*

By N. J. Schlick, Drainage Engineer, Engineering Experiment Station, Iowa State College.

Tests were made on 24-in. pipe, with the types of bedding indicated by the accompanying diagram. The general method of procedure was to bed the pipe in the various ways and then to ascertain their actual supporting strength by applying load through standard upper sand bearing. A hydraulic jack suspended from a beam anchored to two large concrete blocks was used for the loading, the amount of the jack load being indicated on a gage attached to the pump which operated the jack.

The test pipe was laid in a trench dug in made soil. The top soil was a rather close black loam and the subsoil a firm yellow clay. The location chosen for the tests of pipe in earth beddings was such that only the lower portion of each pipe was in clay. In all cases of earth bedding the filling material was loose top soil.

The work was done with labor unskilled in pipe laying. For this reason, and also to insure uniformity in the manner of bedding, the specified dimensions of the trenches and concrete cradles were adhered to somewhat more closely than they probably would be in a drainage practice. Aside from the care taken to insure uniformity the quality of the work was much the same as might reasonably be obtained in any drainage district.

The pipe used were selected at the factory primarily for uniformity. They were evenly burned and were free from structural defects. The concrete used in the concrete beddings was made with gravel from the pit on the campus. This gravel is not an exceptionally high grade and is probably no better than the average which would be used for this purpose over the state. It was screened and then remixed so that 50 per cent would pass a ¼-in. screen. Two grades of concrete were used, grade A, a 1:5 and grade B, a 1:8 mixture of Portland Cement and the remixed gravel.

The tests were made when the concrete beddings were approximately one month old. Classes 4-A, 4-B and 8 were the last put in, so that, because of a slightly shorter time of setting and considerably cooler weather, the concrete did not obtain as great strength as that in the other types of concrete cradles.

The concrete cradles, except those of class 7 were all constructed with the concrete at the sides carried up to a height equal to one-fourth the inside diameter of the pipe above the mud height. In the earth beddings the side filling was carried up to a little above the mud-height of the pipe. In each case this allowed the use of the standard upper sand bearing over 90° of the pipe circumference.

The types of bedding tested might be divided into three general classes, namely, earth beddings, concrete beddings for firm soils and concrete beddings for yielding soils. This division can not be adhered to rigidly as some types of bedding might be used in any soil stable enough to prevent the pipe from settling. This is particularly true of class 7 which was patterned after a concrete bedding tested and by the Philadelphia Board of Public Works.

The first of the earth beddings, class 1, was made in accordance with the "Ordinary" method described in the "Standard Specifications for Drain Tile" of the American Society for Testing Materials except that the pipe were only bedded to a little above the mid-height. The trench was shaped in the bottom to approximately fit the lower 90° of the pipe and the ditch filling shoveled in without tamping. There was quite a wide range in the supporting strength of these pipe, but the average agreed quite closely with the average strength as shown by standard strength tests with sand bearings. Because of this close agreement the average supporting strength of class 1 is taken as a basis for comparing the strengths developed by the other types of bedding.

The second class of bedding was the "First Class" method described in the standard specifications mentioned above. The trench bottom was sloped more accurately and was covered with 1 in. to 2 in. of loose top soil before the pipe were laid. The filling was carefully tamped in, especially at the lower ⅛ points, up to a little above the mid height. The average strength of this class was 28% greater than that of class 1 and there was considerably less variation in the results from the individual specimens.

In the other type of earth bedding, class 9, the pipe were laid in a flat bottomed trench and the spaces between the pipe and the sides of the trench shoveled full of loose earth. No especial care was taken to see that the spaces between the bottom of the trench and the pipe were filled, and examination after the test showed that the filling there was so loose as to give the pipe no support. The average strength of these pipe was 26 per cent greater than those of class 1. This increase in strength is thought to be due to the frozen condition of the ditch filling material at the sides of the pipe at the time the tests were made. There is reason to believe that this type of bedding will usually give lower strengths than class 1.

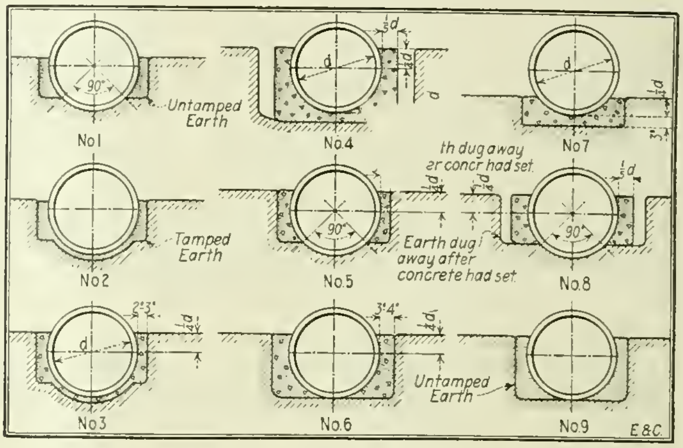


Diagram Showing Nine Methods of Bedding Drain Tile in Testing Supporting Power.

The results of these tests of pipe in earth beddings bring out two especially interesting facts. First: The strength of the pipe laid in the "Ordinary" method agreed very closely with that shown by standard strength tests of similar pipe, and second, that an increase in strength of 25 per cent can be obtained by more careful bedding, as is specified for "First Class" pipe laying. This latter fact is especially noteworthy as in many cases the value of the 25 per cent increase in supporting strength will be much greater than the extra cost of construction, including the salary of an inspector.

None of the pipe in earth beddings would support a larger load than that at which they cracked. All of the tests indicated very clearly that the supporting strength of the pipe after cracking depended upon the bearing power of the soil at the sides of the trench. The soil in which these tests were made was probably more firm than the average in drainage work so that the values of the supporting strength after cracking are valuable for comparing with each other rather than for indicating what may be expected in other places.

The pipe laid in concrete cradles as specified in the standard specifications for "Concrete Cradles" for "Solid Soils" were tested as class 3. The concrete used was proportioned 1:8 as mentioned above. The bottom of the trench was shaped to fit the lower 90° of the pipe and 2 in. of concrete placed on it. The space between the sides of the trench and the pipe, about 2½ in. at the mid-height of the pipe, was then spaded full of concrete up to a height of one-fourth the nominal diameter of the pipe above the mid-height. These pipe had an average cracking strength 64 per cent greater than those of class 1.

Class 5 beddings were a combination of the earth beddings and the concrete cradle just described. The bottom of the trench was shaped to fit the lower quarter of the circumference of the pipe and the spaces between the pipe and the sides of the trench, about 3 in., filled with 1:8 concrete. These pipe showed a cracking strength of 46 per cent greater than those of class 1.

---

*Extract from a paper read at the meeting of the Iowa Drainage Association.

The third class of concrete bedding for solid or firm soils was class 6. The trench was dug with a flat bottom and was about 6 in. to 8 in. wider than the outside diameter of the pipe. The pipe was laid in the trench and concrete poured in at the sides, care being taken to get the concrete well around the pipe. Tests of this type of bedding were made with two grades of concrete. In class 6-a 1:5 mixture was used and in class 6-B a 1:8 proportion. The pipe of class 6-A supported a load 96 per cent greater than class 1 before cracking. Those of class 6-B developed a crackling strength 80 per cent greater than that of class 1.

It is not certain that the tests determined the maximum supporting strength of the pipe of these three classes as the limit of the apparatus was reached on several occasions. When a large load was left on a cracked pipe for any considerable time, the uneven settlement caused derangements in the best apparatus. However, the maximum loads recorded were very large, the average being more than twice those supported by the pipe in earth beddings.

The tests of these classes also indicated that the supporting strength of a pipe after cracking depends upon the bearing power of the soil. For example, the average maximum loads supported by the pipe of Class 6-B was greater than that of the pipe of Class 6-A. These two classes were the same except that the concrete used in Class 6-B was a leaner mixture than that used in Class 6-A. The yielding of the lateral support was a gradual one. These tests all indicated that if the maximum applied load could have been held for a longer time, all the pipe would have collapsed.

The pipe of these three classes showed a marked tendency to develop side cracks at or near, the top of the concrete at the sides. Where the side cracks in the pipe were below the top of the concrete it usually cracked opposite the crack in the pipe. In each case in Class 3, the concrete was cracked along the center-line at the bottom, the crack appearing simultaneously with the crack in the bottom of the pipe. In a great many cases the cradle was cracked near the lower ⅛ points by the continued application of pressure after the pipe had cracked.

The pipe all cracked at the top at the same or less load than at the bottom. In general, the development of a single crack at the top was indicated by a slight decrease in the indicated load, and the appearance of cracks in both top and bottom by a marked decrease in the indicated load. The side cracks usually developed while the load was being again raised to that at which caused the cracks in the top or top and bottom.

The bedding designated as Class 7 was patterned after the Philadelphia method. This type of bedding or cradle would be equally effective in all soils firm enough to allow of the construction. The trench was dug a little wider than the outside diameter of the pipe and the bottom left flat. About 3 in. of 1:8 concrete was placed the full width of the trench and the pipe laid upon it. Concrete was then placed around the pipe to a height of 6 in. or one-fourth the inside diameter, above the bottom of the pipe. This bedded the pipe in concrete for a little over 90° but furnished no side support whatever, as the top of the concrete was just about even with the surface of the ground.

The pipe of this class showed an average strength before cracking 82 per cent larger than those of Class 1. As these pipe received no side support, they collapsed as soon as the main fractures were developed. These pipe all cracked at the top at the same time, or before, they did at other points. In no case did one of these pipe crack through the portion bedded in the concrete. The general failure was at the top and at the sides at the top of the concrete. Some pipe also cracked at one ¼ point at the side but in no case at both sides ¼ points.

An examination after the tested pipe were removed from the concrete showed that each of the concrete cradle was free from cracks. It may be that as great a supporting strength can be produced in the pipe with a lighter cradle of this type. This type of cradle is easier to construct and required less concrete than some of the other types in which the pipe had no greater supporting strengths.

As it was impossible to secure soils which would reproduce the conditions met with in work in what are termed yielding soils, a condition which was more severe was provided. After the concrete in the cradles had set, the earth was dug away at the sides down to the bottom of the concrete. This method gave the pipe no side support except that furnished by the concrete cradle.

Tests were made of pipe bedded in "Concrete Cradles" for "Yielding Soils" as specified in the "Standard Specifications for Drain Tile." In Class 4-A a 1:5 concrete was used and in Class 4-B 1:8 concrete.

The trench was dug 10 in. wider than the outside diameter of the pipe and with a flat bottom. A 3 in. layor of concrete was placed in the trench and the pipe laid upon it. Concrete was then poured in at the sides up to the specified height of ¼ the inside diameter above the mid-height.

The pipe of Class 4-A showed an average strength before cracking 38 per cent larger than those of Class 1, while those of Class 4-B supported 50 per cent more load before cracking than did those of Class 1. The fact that the cradle of the leaner concrete gave the larger support is attributed to the fact that the pipe of Class 4-B were laid before those of Class 4-A and that cool weather and frosty nights prevailed after the cradle of Class 4-A were poured.

The pipe of these two classes usually cracked at or near the four ¼ points at the same time, though the side cracks were often at or near the top of the concrete. In all cases the concrete cradle cracked along the center line in the bottom, and often at about the lower ⅛ points of the pipe, at the same time the pipe developed fractures. After the cradles were cracked in the bottom, the two sections revolved around the lower outside edges and the pipe would support practically no load.

The bedding of Class 8 were very similar to the combined earth and concrete bedding of Class 5, except that the earth was dug away from the outside of the concrete so as to reproduce as nearly as possible the conditions prevailing when this type of bedding is used in yielding soils.

The concrete used in these beddings was proportioned 1:9. It was poured in cool weather and had developed only a comparatively small portion of its final strength at the time the tests were made.

The pipe of this class had an average supporting strength only 18 per cent larger than those of Class 1. The concrete received no side support so that the load which developed the cracks in the pipe was the maximum. These tests indicated that this type of bedding would give but little side support other than that due to distributing the pressure over a larger area. In many soils this would result in a noticeable increase in supporting strength but in very wet soils the increase would be small.

The class of bedding still to be tested will be of the same general type as Class 4, which is the "Concrete Cradle" for "Yielding Soils" of the "Standard Specifications for Drain Tile." The cradles of Class 4 were made with the minimum dimensions specified, while the new type will be designed to safely support a 24-in. tile when cracked at the four ¼ points and receiving the estimated maximum load from ditch filling.

The data given above are from only one series of tests and can not be taken as final until they are verified by further work. There are, however, some very important general facts which are pretty definitely shown.

These results might be summarized in three general statements, as follows:

1. The supporting strength of tile laid in the "Ordinary" method is practically the same as the "Ordinary Supporting Strength" shown by the standard tests.

2. The supporting strength can be increased 25 per cent by more careful earth bedding and 80 per cent or 90 per cent by the use of concrete cradles.

3. The supporting strength after the pipe is cracked depends upon the bearing power of the soil at the sides of trenches, irrespective of the type of the bedding.

MARYLAND EXPERIENCES IN THE DISINFECTION OF WATER SUPPLIES.*

By Robert B. Morse, Chief Engineer, and Harry R. Hall, Assistant Chief Engineer, Maryland State Department of Health.

The engineering investigation of Maryland water supplies, begun in 1912 by the State Department of Health, soon showed that many of the water systems were badly in need of attention. The surface supplies were derived from streams fed by watersheds containing habitations, in many cases providing numerous sources of contamination, and, in general, protection was not offered by long storage, filtration, or other treatment. Water was usually taken from the stream at an intake dam and passed into a distributing reservoir of insufficient capacity to provide a safe period of storage. Moreover, water from some of the tubular well systems was found to be polluted, because the wells either were of too shallow depth and located in the midst of thickly settled districts where sources of pollution were numerous, or were driven in rock containing fissures. Some supplies previously considered to be beyond suspicion were found, upon close investigation, to be in a bad condition and a menace to the public health.

Attractive, Unsafe Water.—In a large number of the instances where supplies were polluted, the water was satisfactory from a physical standpoint, there being an absence of color, turbidity, and other objectionable characteristics. This was naturally true in the case of most well and spring waters. The water from streams fed by mountain watersheds, and from watersheds containing much wooded or uncultivated land, was also generally in good physical condition.

Where water, otherwise acceptable, was found to be in an unsafe sanitary condition, filtration did not appear to be necessary or even advisable for assuring the proper degree of purity. Expense and the improbability of proper operation are two factors which would make filtration plants undesirable for many of the small systems which abound in Maryland. Consequently, disinfection was resorted to wherever it would serve the purpose. There were, however, a considerable number of surface supplies derived from streams flowing through cultivated country and furnishing a water occasionally or persistently turbid. Such supplies as these naturally require filtration. Disinfection in connection with filtration is general, and is required in all new installations. While the writer's assistants have been able to obtain good results from several filter plants without the addition of disinfectants, the character of attention which small works ordinarily receive makes their use essential.

Early Installations.—Prior to the establishment of the engineering division of the State Board of Health in 1912, there were only four disinfecting plants in operation on water supplies in Maryland. Two of these were located on the Gunpowder and Jones Falls systems, of Baltimore; and two, owned by the Baltimore County Water and Electric Company, were at the Avalon and Herring Run plants which serve large sections in Baltimore County near the city. At Avalon, disinfection was carried on in conjunction with filtration. All these installations used hypochlorite of calcium, and at Herring Run ozone was employed at times.

Extent of Water Purification.—Since 1912, many towns in other parts of Maryland have been provided with purification plants, and it is a striking fact that, of the 842,565 persons served by public water supplies at the present time, 745,149, or 88.4 per cent (approximately 54.9 per cent of the population of the State), use water which is treated by either filtration or disinfection, or both. A population of 732,960 is served with disinfected water, 12,189 with water filtered only, and 97,416 use raw water. Thus, 54.1 per cent of the total population of Maryland drink disinfected, 54.9 per cent treated, and only 7.2 per cent raw, water. Of the total number of people served by public water systems, 87.0 per cent use disinfected, 88.4 per cent treated, and 11.6 per cent raw, water.

Not only is the influence of water purification felt by the public water supplies, but it has reached to State and private institutions as well. There are six institutions, embracing a population of 2352, where the water receives treatment of some kind, and in all but one of these it is disinfected. Included in this number are, a penal institution, a tuberculosis sanatorium, and four educational institutions.

Hypo and Liquid Chlorine.—Disinfection by means of hypochlorite of calcium or liquid chlorine is naturally the most common method practiced, although one small mill town uses distilled water, which is the condensed exhaust from the steam turbines in the mill, and there is an ozone plant which is operated in conjunction with one of the hypochlorite installations. There is a possibility that ultra-violet-ray disinfection will shortly be introduced, as its use is under consideration for a mechanical filter plant now being constructed.

The type of apparatus suitable for hypochlorite or liquid chlorine treatment in any particular case depends upon the method by which is supplied. Where the flow of water to be treated is at most times substantially uniform, as in the case of certain pumping plants, or in gravity lines discharging into reservoirs, a manually controlled apparatus is sufficient. Where fluctuations occur in the rate of flow, automatic control devices are essential for proper results. Liquid chlorine plants, so-called, introduce chlorine into the water either as a gas or in solution. The gas feed, usually called "direct feed," is well adapted for use where no water under pressure, for dissolving the gas, can be easily obtained. There are no direct-feed plants in Maryland at the present time, and only one, at Perryville, is regulated automatically, although automatic equipment is about to be furnished at Frederick.

The early disinfecting plants, as stated previously, all made use of hypochlorite of calcium, and with effective results. Those on the Avalon and Herring Run supplies, of the Baltimore County Water and Electric Co., were the first to be installed in the State. The former was constructed in 1908, and the latter during the year following. Late in 1910 the Jones Falls supply for Baltimore was first disinfected, and in June, 1911, the Gunpowder River plant was put into use. Until 1913 these were the only installations of disinfecting apparatus used for water purification in Maryland. A filtration plant had been previously built by the Washington County Water Co., to supply Hagerstown from Antietam Creek during dry periods, and hypochlorite dosing apparatus had been provided, but the disinfectant was not used until the summer of 1913. About the same time, the State Board of Health constructed a plant for the Ellicott City system. Cumberland next followed, during the fall of the same year, by putting into operation a hypochlorite plant in conjunction with the mechanical filters on its new supply. In December, the mountain supply of Hagerstown was furnished with hypochlorite apparatus. A typhoid fever epidemic at Rockville during February, 1914, made necessary the construction of an emergency hypochlorite plant by the State Board of Health for treating the supply, derived from tubular wells driven in rock, and proven to be the cause of the disease. The first liquid chlorine apparatus was put into operation at Union Bridge in January, 1914, for treating about 120,000 gal. of water derived from tubular wells driven in limstone rock. An ozone plant had been installed in 1909 at the Herring Run supply of the Baltimore County Water and Electric Co., but at first it was used, so the writers are informed, only experimentally.

---

*From paper read before the New England Water Works Association.

After the powers of the State Board of Health were broadened, in 1914, and an increased appropriation was provided for sanitary engineering work, water purification plants were naturally introduced at a more rapid rate than previously. At the present time there are eleven liquid chlorine installations treating about 5,600,000 gal. of water daily, and eleven hypochlorite plants treating approximately 90,600,000 gal. daily. Of the latter amount, 80,000,000 gal. are delivered to Baltimore City.

Proposed Installations.—Changes are taking place continually in the water supply situation in this State, and it is expected that the number of disinfecting plants will be soon increased and that alterations will be made in some of the water supplies, which will involve plants now in operation. At Annapolis the existing liquid chlorine plant will probably soon be used in conjunction with a mechanical filtration plant, the construction of which is contemplated, and at the Maryland House of Correction the liquid chlorine apparatus already installed will supplement purification by slow sand filters which were recently designed by the writers, and which will soon be built. A filtration plant is being constructed at Westminster and one is being designed for the Springfield State Hospital. Liquid chlorine will probably be used for both of these installations. Liquid chlorine will soon replace hypochlorite at Westernport, and the same change is being considered for the Baltimore filtration plant, for which hypochlorite was recently quoted at $290 a ton, on the basis of a yearly contract. There is a marked tendency to use liquid chlorine instead of hypochlorite of calcium in connection with old as well as new installations, and the high price which now has to be paid for the latter will stimulate this movement.

Amount of Chemicals Used.—The amount of chemicals used at the disinfecting plants in Maryland has varied widely according to local conditions. It has ranged from 0.2 to 3.0 parts per million of available chlorine in the case of hypochlorite treatment, and from 0.25 to 0.67 parts where liquid chlorine is used. Where the disinfectant is applied to a spring or well water, or to the effluent from a well-operated filtration plant, the amount required is usually near the minimum mentioned above. In the case of turbid waters, larger amounts have been found necessary for proper treatment, and at times of extreme turbidity excessive quantities are required. In the treatment of the Baltimore City water, as high as 3 parts per million of available chlorine, or 75 pounds of hypochlorite to the million gallons, have been used on raw water. The amount necessary in many instances depends also upon the character of attention given the apparatus.

Common Troubles.—It is by no means a fact that the disinfecting plants in Maryland have been operated with complete satisfaction, for most of them have had trouble of some kind. The difficulties encountered could generally have been avoided with more attention to proper operation. With hypochlorite plants, the principal annoyance has been due to the formation of coatings, which clog the pipes; and, where the solution was particularly strong, the materials of which the piping was made have been attacked, necessitating the replacement of parts. These are not serious troubles, however, and can be eliminated by frequent inspection. In the case of liquid chlorine plants, it has been found that occasionally a part becomes corroded and requires replacement, or a valve gets out of adjustment, but the gradual perfection of apparatus is making such occurrences less frequent.

Where faithful and intelligent attention has been given to operation, and the amount of disinfectant used has not been excessive, few complaints have been made regarding tastes or odors in the water. In one instance, where a liquid chlorine plant of the manual control type was disinfecting water, the flow of which fluctuated considerably, there was always an overdose at night which caused complaint due to tastes noticeable during the early hours of the day. This, of course, was the fault of the method employed and not of the treatment itself. In general, fewer complaints have been registered concerning disagreeable tastes where liquid chlorine was used than in the case of hypochlorite.

Results of Disinfection.—There has been a marked decrease in the prevalence of typhoid fever in some of the communities where disinfecting plants have been installed. In most cases, however, the period of operation has been so short, and, on account of the small size of some of the places, the appearance of typhoid so irregular, that records do not indicate clearly the effect produced. Moreover, much of the typhoid fever in Maryland is attributable to causes other than impure water supplies. Nevertheless, there are certain well-defined instances where a decrease in typhoid fever morbidity and mortality can be traced directly to purification of a water supply. In Baltimore, the reduction has been very pronounced. After the disinfecting plants were built, the prevalence of typhoid immediately fell off and the improvement has since continued. In 1915 both the morbidity and mortality rates from this disease, although higher than in many of the larger cities of the country, were approximately half as great as in 1910. Following the introduction into Cumberland of filtered and disinfected water from Evitts Creek, in place of the former raw supply from the Potomac River, the occurrence of typhoid fever was so reduced that, in 1915, there were scarcely more than one-sixth as many cases of, and one-fifth as many deaths from, this disease as in 1913, in spite of the fact that the corporate limits had been enlarged in the meantime. However, the change in source, and the long storage period provided in the reservoir, would undoubtedly have caused a large proportion of this improvement without the presence of a purification plant. One of the most striking instances of the effect upon typhoid occurrence, caused by disinfecting a water supply in Maryland, was that of the Rockville epidemic, which, after 28 cases had occurred, was checked suddenly by the installation of an emergency hypochlorite plant.

In order that prompt remedial measures may be instituted when a water supply is at any time found to be in an unsafe condition, or when an outbreak of typhoid fever casts suspicion on a water previously untreated, the engineers of the State Board of Health are all instructed in the setting up of an emergency hypochlorite dosing apparatus, making use of ordinary and easily obtainable materials.

Conclusions.—Basing judgment on experience in Maryland, it may be stated that, where chlorinating plants for water supplies are given faithful and intelligent attention, their use is decidedly a success; and they provide an effective and inexpensive method for treating many water supplies which do not need filtration, as well as for safeguarding those supplies for which filtration, although desirable, is prohibitive. Unfortunately, there seems to have been some tendency among manufacturers to convey the impression that little attention need be paid to the operation of a liquid chlorine plant. This has given the operator the impression, in some instances, that the apparatus can be entirely neglected. While it is true that little or no difficulty need be experienced, except when parts give out, neglect is certain to cause irregularity in dosing, exposure in certain cases to freezing, and other undesirable results. Greater efficiency from some of the disinfecting plants in Maryland is to be expected in the future, as the State Board of Health will be enabled to make more frequent inspections than in the past. This will be made possible by the fact, in addition to the main office of the engineering division, there are maintained four offices in various parts of the State, at each of which there is a resident engineer who has direct supervision over sanitary engineering matters in his district. Without an effective system of control, disinfection would fall short of giving entire satisfaction in connection with many small water supplies.

FOUNDATION CONSTRUCTION FOR CONCRETE PAVEMENT.*

By W. M. Acheson, Division Engineer, Commission of Highways, Syracuse, N. Y.

Where the soil conditions develop that cannot be corrected by replacing with more stable soil, sub-base should be laid. From a study of the highways which were built in Division 9 during the past two years, I have found the following type of foundation course the best for concrete pavements:

After the necessary excavation has been made and properly drained, a layer of clean gravel from 2 to 4 in. in thickness is spread over the bottom. On this place a quarry or field stone course of the required thickness, depending upon the soil conditions. After the voids have been filled with clean sand or fine gravel and the base consolidated, it should be covered with at least 2 in. of coarse sand. This last mentioned sand layer serves the double purpose of regulating the subgrade, and acting as a cushion to take the impact off the pavement proper.

THE STERILIZATION OF CHICAGO'S WATER SUPPLY.

For the past five years very thorough-going studies have been made in Chicago to determine the best method of sterilizing the city's water supply. These studies have recently been completed—the responsible officials are satisfied that they have very thoroughly canvassed the situation and all economically available means of sterilization and that they have arrived at the correct solution of the problem. It has been decided to install liquid chlorine plants, at all the pumping stations, with which to sterilize the city's entire water supply.

Just about five years ago the experiments were begun with hypochlorite of lime. At that time, it will be remembered, hypo was in the ascendent—it was the best available disinfecting agency both for temporary and permanent installations. The use of hypo in Chicago was, of course, found feasible, but its use presented certain problems of a serious nature. Some of these were of common type; others were peculiar to Chicago conditions. Thus, had sterilization with hypochlorite of lime been determined upon, it would have been necessary to construct expensive buildings, with which to house the requisite equipment, at each of the city's nine major pumping stations. The magnitude of this problem alone can be realized when it is recalled that the Milwaukee hypochlorite plant cost around $12,000 and the pumpage in that city is only one-twelfth of that in Chicago. Again, the quantity of the chemical required would have been so enormous that very extensive storage facilities would have been imperative in order that purchasing could have been done to advantage and the fluctuating demands met at the same time. Again, several of the pumping stations are situated in residential districts of the city. The use of large quantities of hypochlorite at these stations would have inevitably led to the liberation of large amounts of chlorine gas which would have been highly objectionable to nearby residents. While surveying these difficulties liquid chlorine came into prominence and experimental studies were begun with it as a disinfecting agency.

As is well known the water supply of Chicago is drawn, by means of crib and tunnel systems, from Lake Michigan. The several cribs presented the ideal sites at which to install the chlorinating apparatus. The long tunnels gave the advantage of a long contact period between the time of application and the time of consumption. Summer conditions presented no formidable obstacle to this plan, but it was believed that winter conditions would render chlorination at the cribs impractical and unreliable. Accordingly experiments were conducted, during the recent winter months, with a liquid chlorine apparatus installed at the 68th Street crib.

As anticipated by the officials the arrangement proved unreliable. Ice trouble made the plan inoperative. Anchor ice formed around the feed pipes and this ice when struck by heavy floes of ice offered sufficient area so that enormous torsional and bending stresses were set up in the feed pipes and the protecting timbering. The result was that both the timbering and the pipes were broken off, putting the plant out of commission.

This difficulty when considered in connection with the fact that the cribs are sometimes inaccessible for periods of several weeks during the winter season clearly demonstrated the impracticability of the crib installations. The cribs can be reached only by tug and the ice floes are sometimes so heavy that it is impossible to reach the cribs during these long periods for the purpose of taking out either minor or major repair parts. It was decided, therefore, that the chlorination apparatus should be set up permanently at the pumping stations.

An order has just been placed by the city with the Electro Bleaching Gas Co. of New York City for furnishing and installing 19 chlorination plants. Several similar plants have been in operation at the pumping stations for several months and have given entire satisfaction. When the recently ordered plants are received and installed the city will have 30 of these chlorinators in service. The physical conditions are such that at some stations two or more chlorinators are necessary.

The five-year study of the comparative merits of hypochlorite of lime and liquid chlorine, as conducted in Chicago, has shown that the latter is preferable from the standpoint of installation cost, fixed charges, operating expense, flexibility and precision of operation control, and reliability. Moreover, the nuisance arising from the use of hypo in large quantities in residential districts is entirely avoided by the use of liquid chlorine. The Chicago officials are well satisfied that they have arrived at the best solution of the great problem of disinfecting the city's entire water supply.

EFFECT OF FILTER ALUM ON BRASS PIPE.

The experience of the Hackensack Water Co. with reference to the effect of solution of filter alum on brass pipe and fittings are reported as follows by Mr. G. R. Spalding:

1. Ordinary brass pipe and heavy pattern fittings may be expected to give several years' service conveying alum solutions of 8 per cent strength or less.
2. Threaded pipe will give more or less trouble from leaks at the joints and will have to be taken down and rethreaded at least once during the possible life of the pipe. Slipjoint fittings present distinct advantages over ordinary threaded ones because of the above consideration.
3. For conveying alum solutions of more than 8 per cent strength brass is not suitable.
4. Increasing the temperature of alum solution greatly increases its solvent action on brass.
5. The presence of iron in certain forms in filter alum seems to increase its corrosive action upon brass to a marked degree.

Lighting the Panama Canal.—The United States is largely indebted to the efforts of Swedish engineers for an economical means of lighting the Panama Canal. In Sweden the reefs and narrow inlets are a menace to skippers and fishermen, but the expense of engaging lighthouse keepers and providing them with the means of livelihood would be so great that many dangerous points had necessarily to be left unguarded. That resulted in Gustaf Dalen creating the self-tending lamp, which affords a practical and economical means of light. From that was finally evolved the Aga gas accumulator,' which contains 100 times its own volume of gas, and is, at the same time, safe and nonexplosive. It can be fixed to burn for a year or even a longer time without personal attention. The Aga flashlight apparatus also makes it possible to give distinctive characteristics to lights, of any desired duration or combination, while another marvel of this economical device is the sunvalve, which extinguishes the light during the day, thus further diminishing gas consumption. It is that type of lamp that has been installed along the Panama Canal.

---

*Extract from a paper read before the American Concrete Institute.

Engineering and Contracting

Devoted to the Economics of Civil Engineering Design
and to Methods and Cost of Construction

EDITORS

H. P. Gillette C. S. Hill C. T. Murray S. C. Hadden C. W. Malcolm

Volume XLV. CHICAGO, ILL., MAY 3, 1916. Number 18.

ANNOUNCEMENT OF A NEW EDITORIAL FEATURE.

In this issue will be found a new editorial feature, the main claim to its novelty consisting in the publishing of a large number of engineering nuggets of knowledge, or, dropping metaphors, in giving many short articles containing usable suggestions.

Our older readers will recall that ten years ago we introduced the practice of publishing about a page of construction "hints" each issue—a practice that has since become quite common among engineering papers. But now we are about to enlarge that feature to such an extent as to warrant speaking of the dozen pages of "nuggets" in this issue as being a novel feature.

Engineering and Contracting originated the "methods and cost" type of article more than a decade ago. Much criticism was leveled at us for undertaking to publish "cost data," but we have lived to see the criticism of the bitterest critics change from virulency to not worse than damnation with faint praise.

We anticipate no adverse criticism of the new feature herewith presented, save in so far as we find ourselves unable to live up entirely to the high standard that we have set for ourselves. Our object is to pan the gravels of fact in search for nuggets of usable fact.

"History," said Herbert Spencer (we quote him from memory), "is a compendium of facts, but facts that are, for the most part, useless. It is a fact that my neighbors cat gave birth to kittens yesterday. Of about equal parity in value are dates of births of kings, and scarcely more in value to us are the records of their reigns."

Engineers have written articles and papers till libraries groan under the load of them. Every author of an engineering book, however, can testify that amid the vast mass of fact published as engineering literature, there are precious few facts that are both novel and "usable." A book author, seeking material, wades through a long article and feels quite repaid if he is able to glean from it even one short paragraph for his book. Why, he asks himself, did not more of these many prolific writers have in mind me—the author of a book seeking usable facts? And then there flashes upon him the thought that engineers and contractors who are not authors, and never expect to be, might well ask a similar question. Their lives are too short of days and their days too long of working hours to give time to do more than glance at most of the engineering literature that comes to their attention. And, as they grow older, having learned the non-utility of so much of the current technical literature, they grow even less studious of it than they were at the beginning of their career. Clearly something is wrong, and it seems to us that the fault has been, in large part, ours as editors. We have spread before our readers feasts so bountiful that they have gagged at the banquet.

This, at any rate, is our present belief, and we have decided to initiate a radical change in the general plan of editing an engineering paper. As indicated, we purpose featuring short articles. There are, of course, some topics that must be treated at greater length, partly because there is a limit to the condensation of facts, if all the significant facts are to be given, and partly because a diet consisting entirely of condensed food is apt to become as repellent as a diet diluted to the n th power.

Engineering and Contracting hopes, in a word, to retain its old flavor of practicality while adding thereto a new tang that comes from greater condensation. The complete development of this change will require time and for the present only every third or fourth issue will contain the proposed short articles section. As means of collection and preparation are increased the section will appear more frequently until it is an important feature of every issue.

CLAY CURING BLANKETS AND CLEANING CONCRETE FOR BITUMINOUS COVERING.

Application of bituminous carpet to concrete pavement requires a substantially clean surface if adhesion is to be insured. It costs from ⅓ ct. to ½ ct. per square yard to sweep clean a concrete pavement for carpeting. These costs do not include removal of the earth curing blanket; they are costs of sweeping clean the pavement from dried dust left from the earth covering or wind driven onto the street surface. They are also costs where a fine, friable earth covering has been used. Cleaning concrete for bituminous carpeting when a clay blanket has been used for curing is a far more difficult and expensive task. Ordinary sweeping will not remove an adhering film of clay from concrete pavements. Scouring with wire brooms or flushing and scrubbing are about the only successful means. These processes multiply the cost of final cleaning several fold. Road builders having bituminous carpeted concrete pavements to build should bear these facts in mind in choosing materials for the earth curing blanket. A clay blanket should be avoided where practicable. It not only costs more, where clay is used, to clean the concrete for carpeting, but the cleaning is not so certain and chances of peeling are increased.

THE ENGINEER AND THE POLITICIAN.

Why is it that after all these years of political pulling and hauling engineers have written so little about the art of handling the politician? There must be hundreds if not thousands of city and consulting municipal engineers in this country who have formulated some sort of general strategy for their guidance where a conflict with politicians cannot be avoided. We believe it would be highly beneficial if some of our old campaigners would formulate a set of fundamental principles for the guidance of the raw recruit, in the municipal engineering field, in his unavoidable dealings with politicians.

In many cases important engineering enterprises are carried to a successful conclusion with comparatively little opposition from the forces of nature, but with great opposition from men. All the real difficulties encountered in such cases are imposed by men who oppose the project. The engineer describes his works, which have given him little trouble, in an article or paper of considerable length, but only a sentence or two, at most a paragraph, is devoted to the nature of the political opposition encountered and the means employed in overcoming it. Such engineering articles are very incomplete—what they give is less important than what they omit.

When it is remembered that many promising engineering projects never get beyond the project stage, because of political opposition, and that others are dwarfed from the same cause, the importance of this subject to the engineer is appreciated.

Many engineers may be reluctant to relate their adventures and methods of procedure in the political arena for fear that they will thereby partially disarm themselves while adding to the number of their opponents and to the violence of their opposition. This fear may or may not be well founded, depending on a number of things. Obviously it would be unwise for a city engineer to write an article for publication over his own signature telling how he manages to get along with the politicians of his own city. But no harm could come to him if he wrote over a pen name, particularly if he wrote about things which had been disposed of, politically, for some years. Moreover, many engineers have crossed swords with politicians in other cities than that in which they are now working. Why not write about former engagements when on political topics?

Probably most engineers look upon the politician as an evil to be eradicated rather than as a force to be recognized and reckoned with. This, we believe, is the view of the citizen whether he be an engineer, preacher, blacksmith or what not. It may be safely assumed, however, that the politician is here to stay as long, and probably a little longer than the rest of us. He is shrewder than other men and he knows more about them than they know about him—that is his business. Politicians will become extinct when taxpayers do and not one minute before that time.

If the politician is here to stay, and he certainly is, why not recognize that fact and make a study of how to handle him the same as we do of other obstacles encountered in carrying on engineering work? We believe this can and should be done.

Some will say there are many kinds of politicians, and this is true, but they doubtless have, from the engineer's viewpoint, many distinctive traits in common. We believe it is quite feasible to formulate a set of fundamental principles to guide the young engineer in his dealings with politicians. Frankly, the editor is unable to do this, but he hopes those who are well qualified to do so will undertake the task. The subject possesses the merit of novelty and would be well received, we are positive, in many quarters.

While the editor's experience with politicians has been slight he has observed a few things about them which will be set down here by way of illustration and as introductory to a further discussion of the subject should anyone feel moved to take it up where we leave off. Politicians are industrious people who act promptly. Oftentimes they will talk themselves out if given time enough. If unopposed they will sometimes take enough rope to hang themselves. Just as their opposition is a thing to be avoided their co-operation is a thing greatly to be desired; usually it can and must be secured. Politicians are progressing along with the rest of us and many of them realize that the best politics is that which has the sanction and support of the expert. There is very little personal feeling between political opponents. This must be evident to anyone who observes the antics of our national lawmakers. It doesn't pay to get angry with a politician—it does pay to be on good terms with him socially. He has his good side, like other folks, and if approached from that side may keep his other side, like the back of the moon, always turned away.

PROPOSED GOVERNMENT REGULATION OF THE PRICE OF ARMOR PLATE.

Following the passage of a bill by the Senate to construct a $11,000,000 armor plant, the Bethlehem Steel Co. has published an offer to make armor for war vessels at a price to be determined by the government itself. This offer may almost be characterized as epoch making, for it is the first great step toward government regulation of prices, other than the "rates" of the railways and so-called public utilities.

Over the signatures of Chas. M. Schwab and Eugene G. Grace, the Bethlehem Steel Co. says:

"We offer to let the Government's own agent, the Federal Trade Commission, fix the price. We agree to make that offer good indefinitely. We can and will manufacture armor at a price cheaper than the Government can possibly do it."

This, we repeat, is an epoch making step. It marks the beginning of the end of the old political doctrine that prices of commodities should be regulated entirely by competition. When one of the greatest manufacturing corporations in the world voluntarily seeks price regulation of a product that it sells to the government, other similar offers will inevitably follow.

The Bethlehem Steel Co. states that it has $7,000,000 invested in armor plants, and it admits that most of this investment would be lost were the government to build a plant of its own. This admission is heralded by some newspapers as evidence of pure selfishness on the part of the company in now making a "belated offer" of nearly 10 per cent reduction in its price for armor. Granted, but what of it? Shall the discovery of a selfish motive in a bargain serve to lead to the rejection of its terms? If so, bargaining of every kind must cease. The question that primarily concerns the public is whether the Bethlehem Steel Co. has or has not made a fair and reasonable offer.

As to the reasonableness of its proposed price of $395 a ton we are not able to speak. As to the fairness and saneness of its proposed offer to submit armor price regulation to a federal commission there is not the slightest doubt. The business men of America, through chambers of commerce and otherwise, should insist upon an acceptance of this offer.

COST OF PROVISION FOR TRAFFIC DURING ROAD CONSTRUCTION.

In estimating the cost of concrete road construction inadequate consideration is often given to the item of cost of provision for traffic during construction. This cost item is not peculiar to one type of road construction, but cost of providing for traffic during construction of concrete roads is emphasized in importance because of the comparatively long period during concreting and after the pavement is laid, when no traffic can be permitted. With concreting progressing at a rate of 300 ft. per day, which is not a poor average; with subgrade being prepared two days' run ahead of the mixer, and, with a curing period of two weeks, not less than ¾-mile of road is under construction. The period which this length of road is out of commission is not less than two weeks. For this distance and period of time traffic must be cared for elsewhere than on the road being rebuilt. It must also be cared for, and here is the complicating factor, some time during the season for two weeks for every three-quarters of a mile of the season's mileage constructed. These statements are sufficient to indicate the possible intricacies of the problem.

Costs of detouring traffic in road reconstruction have been stated separately in no published records familiar to the editor. It is known, however, that in instances they have been several hundred dollars per mile of road built. In other instances they have obviously been insignificant. In speculating about the subject, the first conclusion must be the trite one that local conditions determine the needs in each case and therefore the cost in each case. In towns alternative routes are commonly available for detouring traffic, in the country this opportunity is rare, and special detour roads must be temporarily provided. The cost of these temporary detours varies with character, volume and weight of traffic, with the availability of detour road locations, with the season, with the weather and soil conditions. There is no end of variables that may reasonably enter into cost of providing detour roads.

As already stated, costs of providing for traffic during road construction have not been separately recorded.

The object of the present comment is first to disclose such costs possessed by our readers, and, second, to emphasize the need of having the possibilities of such costs in mind in estimating concrete road construction. If success greets the first object, the second is bound to be greeted by success. We look to our readers for successful accomplishment of both objects.

THE SAFE PERIOD FOR ADMITTING TRAFFIC TO CONCRETE PAVEMENTS.

Three weeks after laying is usually considered a safe date for admitting traffic to a concrete road. At least this period is usually as great as a long suffering public will suffer without demanding access to the road. Obviously concrete three weeks old is in a very early stage of its development to full strength, and whether it will be injured or not by traffic will depend upon the nature of the traffic. The rubber tires of an automobile or even the steel tires of a wagon may cause no damage on concretes on which a traction engine with lugged tires would show a mark for every lug. Concrete three weeks old is ordinarily not hard and tough enough to withstand concentrated abrasive or crushing load such as a traction engine might easily bring upon it. To demand, however, that all traffic be prohibited until the concrete has reached a strength beyond danger of damage from occasional kinds of vehicles and load is manifestly unfair. A suggested practice would be to open the road first to ordinary vehicles and at some later date to all traffic of any sort.

WORDS, WORDS, WORDS.

When one enters a large engineering library there is apt to come upon him a feeling of dismay. The serried shelves reach away in endless number. The place seems a very dismal swamp of literature, depressing because so vast and impassable. Such at least is the impression often produced upon one who goes there with no definite object, but rather to get a general view of "how the engineering world moves."

Numberless current periodicals and bulletins lie about. A case stands full of the latest books. These are in the forefront. Back of them, on all sides, are crypts full of words laid to rest in their stiff covers—a rest that is rarely disturbed, for, be it known, relatively few engineering volumes in these libraries are read after the tenth year of their interment. An occasional curious student scans the epitaphs on the covers, and less occasionally peers in upon the remains. But, as we have said, the peace of the tomb is upon most of these tomes and always will be.

As an author of books the editor has often conducted exploratory expeditions among the most ancient catacombs of technical literature, and, after digging for an hour or more, has felt a throb of pleasure at the discovery of a bit of information suitable for his projected book. The rarity of valuable information—data suitable for a modern engineering book—is attributable less to the "changes in the art" than to the tendency to record facts that are not complete enough to be much more than vaguely suggestive.

Engineering is primarily an economic science. In the final solution of every economic problem each factor must be expressed in money or in units convertible into money. Hence there must be numerical data before any problem in economics can be solved. The truth of this proposition is almost if not completely self-evident. Yet, like many another truth, it seems rarely to have impressed itself with full force upon men. Were writers on engineering topics fully appreciative of the fact that the final goal is usually the minimum unit cost, there would be found fewer qualitative expressions and vastly more quantitative data in their articles and books.

There may be almost infinite known ways of accomplishing a given result, but only one of these will give a minimum unit cost under the given conditions. To select this one best way is the problem of the engineer—a problem that cannot be even roughly solved without the possession of many quantitative data. Ten years ago relatively few articles contained cost data. Today the majority of articles leave one in the dark as to the economy of the method or design that is described.

It is both amusing and exasperating to read hot debates on this or that material, this or that method, this or that design, the debaters fruitlessly seeking to solve the problem in economics by the mere phrasing of ideas, apparently blind to the fact that mere words can no more overtake an economic fact than a stuffed hawk can catch a rabbit.

A recent writer argues at great length the economic necessity of mixing concrete a long time in order to set free more of the colloids that cause cementing action. The colloid theory may be sound, but it is a purely qualitative theory as yet, and can be used to prove nothing as to the desirability of long mixing. Nothing but actual tests yielding quantitative results will serve, yet this writer vainly tries to substitute language for the data that he needs but does not possess. He is typical of those who have helped to fill the shelves of our engineering libraries.

When Robinson Crusoe was in doubt about some procedure he was accustomed to marshal the "fors" and the "againsts" in two parallel columns. Apparently, if he could think of more "fors" than "againsts," the "fors" had it. Not a little engineering reasoning has been of this primitive character. It happens, however, that when each of the "pros" and "cons" is expressed in dollars, a single "con" may outweigh all the voluble "pros" of all the tongues that have made utterance on the subject.

Let the engineer keep ever in mind that he is an economist and that economics is quantitative. Anything that is merely qualitative may have interest to the economist, but cannot find place in a unit cost equation until experiment reduces it to a quantitative basis.

THE PROPER LOCATION OF REINFORCEMENT IN A TWO-COURSE CONCRETE PAVEMENT.

The committee on Reinforcement at the latest National Conference on Concrete Road Building made positive objection in its report to locating reinforcement in two-course concrete pavement in the plane of juncture of the base and top courses. Since the usual top course is 2 in. or thereabouts, thick, the committee named recommended placing reinforcement 3 in. deep to avoid location "at the juncture between the base and wearing surface, which is objectionable." In view of the fact that this charge of objectionableness is a direct criticism of common practice it becomes interesting.

The most recent specification for two-course reinforced concrete pavement that has come to the editor's desk says: "The reinforcing metal shall be placed upon and slightly pressed into the concrete base immediately after it is placed." In connection the specification stipulates: "The wearing course shall be placed immediately after mixing and in no case shall more than 45 minutes elapse between the time that the concrete for the base has been mixed and the time the wearing course is placed." Of ten two-course reinforced concrete pavement specifications that happen to be at the editor's hand only two locate the reinforcement at any place except at the juncture between base and top courses. Incidentally all of these ten pavements have been constructed two or more years and no word has escaped to outside engineers that troubles have developed due to faulty location of reinforcement. As a matter of fact, of course, concrete pavement engineers are pretty much at sea upon the whole subject of reinforcing. To review the many conflicting opinions is a task that cannot be undertaken at the moment, but we may ask what is objectionable in two-course pavement construction in locating reinforcement in the plane of junction of the two courses.

Consider a 7-in. two-course concrete pavement, with a 2-in. top course. There is no reason for locating the reinforcement in this pavement 3 in. instead of 2 in.

from the top except to escape location in the plane where the two courses join. Location in this plane is objectionable only upon the assumption that it is a plane of weakness in the slab. That the joining of fresh concrete surfacing to setting base concrete may easily develop a plane of weakness is obvious. That it need form such a weak plane is not true. What the result will be is purely a question of workmanship. If well known rules of procedure are followed there is as little chance of faulty joining of top and base courses of a two-course concrete pavement as there is of faulty work in any of the other normal construction processes involved. Also whether or not there is a structural disadvantage in placing the reinforcement between courses there is a decided constructional advantage in so doing.

JUDGING THE QUALIFICATION OF MEN FOR ENGINEERING POSITIONS.

During the past two or three years there has been much discussion of the subject of engineering education. In a few cases constructive criticism has been offered, but in general the discussion has produced little of real import. This is to be expected as the subject is one which will not lend itself to quick and easy solution. Those who expect changes of a revolutionary nature are apt to be disappointed, and rightly so. Three factors have contributed to a revival of discussion, namely, the decrease in the number of civil engineering students in most of our engineering schools, the various movements intended to secure wider recognition of the engineering profession and greater returns to its members, and the investigation now being conducted by Professor C. R. Mann, working under the auspices of the Society for the Promotion of Engineering Education and of the other national engineering societies, but at the expense of the Carnegie Foundation. Professor Mann, in an attempt to suggest a basis on which an engineer may be judged, has offered the following score-card of qualifications:

	Percentage.
Character	41.0
Judgment	17.5
Efficiency	14.5
Understanding of men	14.0
Total general	87.0
Knowledge of engineering science	7.0
Technique of practice and business	6.0
Total technical	13.0

As pointed out by Professor A. Marston, in a recent address before the Chicago alumni of Iowa State College, such a score-card leads to absurd results if one tries to apply it as a guide in the selection of men to fill engineering positions. In an attempt to test the practicability of such a system Professor Marston, who as dean of an engineering school and state highway commissioner is required to pass upon the qualifications of a large number of men seeking responsible engineering positions, has applied the proposed test to some engineers and business men of his acquaintance. The engineers considered by him included a city engineer of a city of 5,000 inhabitants, a railway assistant engineer, and an engineer in general practice. His list of business men included a prominent grocer, a well known clothing merchant, and a prominent banker. The result of this hypothetical case was that the business men got all of the engineering positions.

We call attention to the above merely to indicate the absurdity of attempting to select engineers on such a basis. Any definite system for selecting engineers must be capable of application to the young engineer and to the recent graduate of an engineering school. The proposed test certainly would be of little value in judging the engineering ability of such men. The experienced engineer very properly is judged on his past record—a stock-judging contest is not necessary. We seriously doubt if Professor Mann will accomplish much in his attempt to solve the problems of engineering education by centering the attention of engineers and educators on score-card systems of such doubtful value.

EDITORIAL PARAGRAPHS.

When a waterworks is first installed in a village, it is not easy to persuade the users of wells to forego the "old oaken bucket." The writer once got action in such a case by publishing a series of articles in the local paper describing the typhoid fever germ and its subterranean peripatetics. There was at the time a typhoid epidemic, which gave point to the "story," and rush orders for service connections flowed in upon the water company at once. This instance serves also to illustrate that every good advertisement benefits both the buyer and the seller.

What one of us would not profit from a course of lectures on "Thrift"? The Y. M. C. A. has been instrumental in having such lectures delivered to railway employes and their families. Simple "forms" for recording daily expenses, under about 12 heads, are provided, and the men are taught how to fill them in—and keep on filling them in until the practice has become habitual. Another query: Why don't our public schools teach household and personal accounting? Cost analysis is the parent of thrift.

Four water power bills are now in progress through Congress not including the amendment to the Chamberlain army bill which provides for a $15,000,000 water power plant for nitrogen manufacture. Each of these bills has so far progressed half way through Congress, or in plain terms each has passed either the House or the Senate and has the remainder of the way to go in generally hostile territory. A very good outline of these several bills can be had from the Water Power Development Association at Washington.

Apropos of the Army bill amendment noted, it has been interesting to observe the avidity with which the European war has been grasped as an argument for American water power development. Water power promoters throughout the country have burst into rhetoric over the particular importance and notable financial prospects of their projects as parts in nation wide preparedness and the circularized public has heard more of nitrates in the last few months than in all time before.

The experts of the Bureau of Mines reporting upon gasoline production state that hope of a supply commensurate with the increasing demand depends upon the development of a method for "cracking" the atoms of crude oil and thereby releasing larger percentages of the distillate than are now recovered. America in the past has not had to think much about "cracking" the atoms, but the time is commencing when it must if new supplies of the things it needs are to be released for use.

The Secretary of the Navy estimates that the government can make armor at $263 a ton with a 10,000-ton plant running continuously at full capacity. Mr. Schwab points out that the $263 does not include interest, taxes, insurance, depreciation and general expense. But what are such little items like that on a $11,000,000 armor plant? Of course Secretary Daniels himself makes no such charges on his own newspaper plant. And of course his presses and typesetting machines are always working continuously, so why should an armour plant ever cease armor making at full capacity even for a day?

COMMENT ON DESIGNING COMPRESSION MEMBERS FOR SMALL STRESSES.

To the Editors: In reply to your invitation for discussion of the article entitled "Designing Compression Members for Small Stresses," published in Engineering and Contracting of Apr. 19, 1916, permit me to offer the following:

The matter discussed in that article first came to the writer's attention in a design of four-angle columns in a mill building for the Old Dominion Portland Cement Co.'s plant, built by the Virginia Bridge & Iron Co.

A design was submitted in which laced columns, of the proper size to carry the load and conforming to the limiting lengths of l and r, were used. The request was then made to change the design to include a web plate in the columns instead of the lacing bars, and Mr. Lewis, chief engineer of the Virginia Bridge & Iron Co., insisted that the size of the angles be increased to comply with the letter of the specifications. However, the load had not been increased and the angles, if anything, had been more effectively tied together. Then why was it essential to increase them?

The writer believes it was not necessary, and has since recognized this principle in the "Standard Specifications for Steel Highway Bridges and Concrete Foundations" of the Memphis Bridge Company, a clause of which reads:

> No compression member, however, shall have a length exceeding 140 times its least radius of gyration, except those for lateral and wind bracing, which shall not exceed 160. In figuring the radius of gyration, webs of columns and beams and inner legs of angles forming struts may be omitted, provided that the remaining flanges have the required area.

The writer has in his note book the following table for areas and least radii of gyration, counting flanges only as effective, i. e., deducting web tangents:

Section.	Net area, sq. in.	Radius of gyration.
6-in. I 12¼-lb	2.57	0.84
7-in. I 15-lb	3.11	0.91
8-in. I 18-lb	3.64	1.00
9-in. I 21-lb	4.28	1.08
10-in. I 25-lb	4.89	1.17
12-in. I 31½-lb	5.85	1.26

This assumption no doubt is still on the side of safety, as the omitted portion does carry some load.

It is to be noted that this rule does not increase the total which the strut is figured to carry, except in reference to the limiting lengths of l/r. In other words, if the unit stress is low a greater value of l/r can be used (r being the radius of gyration of the total section). Moreover, the column is just as safe as one carrying a higher unit stress with a lower value of l/r. The principle here considered is certainly one which should be taken into consideration in designing.

Very truly yours,

Vernon H. Smith,
President Memphis Bridge. Co

Memphis, Tenn., Apr. 20, 1916.

FURTHER COMMENT ON DESIGNING COMPRESSION MEMBERS FOR SMALL STRESSES.

To the Editors: Professor Smith's article, "Designing Compression Members for Small Stresses," in Engineering and Contracting of April 19, 1916, is of exceptional value because it presents a rational suggestion for meeting a situation which occurs frequently in steel designing. As he points out, the clause in specifications and building codes limiting the values of l/r for compression members to not over 120 or 150 is annoying when stresses are small. Two cases will be cited:

The design of a building was passed upon favorably by a city building department. During the progress of the work the designer decided to use web plates instead of lattice bars for the columns. The web plates would increase the l/r from 110 to 130. Although the area of cross section would be increased the building department rejected the proposed change, giving as a reason that it conflicted with the provision in the code that no column should have an l/r greater than 120. It was only after some argument that the change was allowed.

In another city a building was being extended. The longitudinal struts of the lower chord bracing system of the roof were 14 ft. 10 in. long and were made of two 3½x2½x¼-in. angles placed back to back. They carried only a nominal stress and well served their purpose. It was proposed to use struts of the same size in the extension, but the building department objected because the l/r exceeded the 120 or 150 required by the code. Upon the insistence of the building department, struts made of two 5x3x5/16-in. angles were used.

The handbooks give the least radius of gyration of the two angles shown in Fig. 1 to be 1.26. For an l/r of 150 this radius of gyration permitted a length of 15 ft. to be used. If the shaded portion only is considered effective the least radius of gyration will be 1.68 in., and 150 l/r equal 252 in., or 21 ft. According to the formula 19,000,000 l/r the permissible unit stress for struts with 150 l/r is 4,000 lb. per square inch. The earea of the shaded portion (see Fig. 1) is nearly 1.25 sq. in., which permits a compressive stress of about 4,500 lb.

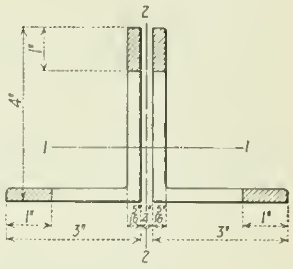


Fig. 1.

The rule of Professor Smith has its limitations and cannot be used indiscriminately. In addition to eccentricity, shock, and rust, the bending of struts due to their own weight should be considered. But in most cases the rule can be followed with satisfactory results.

Very truly yours,

R. Fleming.

American Bridge Company, 30 Church St., New York, April 24, 1916.

COMMENT ON BIDDING ON CONCRETE BRIDGE WORK.

To the Editors: The editorial in Engineering and Contracting of April 19, 1916, entitled "Bidding on Concrete Bridge Work," raises some very interesting questions which should set a great many bidders on this class of work to thinking.

During the past few months the writer has noted quite a number of different cases where the variation in bids was practically as great as in the Dayton cases cited. Recently the writer prepared an estimate and submitted a bid on a small bridge near Newark, N. J., and was seventh out of twelve bidders. The low bid was $22,000, the second bid $27,300, the third bid $27,442, while the twelfth and highest bid was $38,889. In this case the ratio of the first to the second bid is 1:1.24, and that of the low to the high bid 1:1.76.

The plans and specifications contained many costly requirements which would have been eliminated in many cases and materially lessened in other cases had the design been prepared by an experienced concrete bridge engineer. The plans also infringed four distinct patent rights, the responsibility for which, according to the specifications, the contractor was to assume. In other words, the proposition was an extremely expensive one from a construction standpoint. Eliminating all hope of a profit, all charges for overhead expense, superintendence, liability insurance, premium on bond, incidental expense, depreciation on tools and machinery, moving plant, and sundry other items, it would still have been impossible to perform the actual work at the contract price without losing money.

From a comparison of a large number of bids on concrete bridge work in various parts of the country, the writer has reached the conclusion that on the smaller concrete bridges, ranging in cost from $15,000 to $60,000, an average of 35 per cent of the bids is the result of guesswork rather than carefully analyzed estimates. He is inclined to believe that some of the contractors on concrete bridge work would drop dead from heart disease if they were shown a statement of accounts entering into a piece of construction work, which had been prepared by a competent accountant. The writer believes it would be of interest to the readers of Engineering and Contracting to hear the experiences of other contractors on this subject.

Very truly yours,

J. Edward Cassidy,
Chief Engineer, Foster Construction Co.

Newark, N. J., April 20, 1916.

Current Engineering Practice Briefly Recorded

PORTABLE CANVASS STOREHOUSES FOR CEMENT FOR ROADWORK.

On the Easton-Allentown concrete road being built by the Pennsylvania State Highway Department as exemplification of most modern practice for concrete road construction all concrete materials are hauled onto the work by an interurban trolley railway which parallels the roadway. Excellent distribution is possible by this means of haulage. One feature of this distribution is the unloading of cement in bags at measured distances and storing it in the canvass "houses" illustrated. One of these houses holds 90 bags of cement. When the rearmost house is emptied it is carried ahead. One picture here given is a near view of a single house; the other shows the houses placed along the road and the windrow of aggregate opposite. Wm. D. Uhler is chief engineer of the Pennsylvania Highway Department.

CLEANING OUT LOCK GATE TRACKWAYS AT CHARLES RIVER DAM.

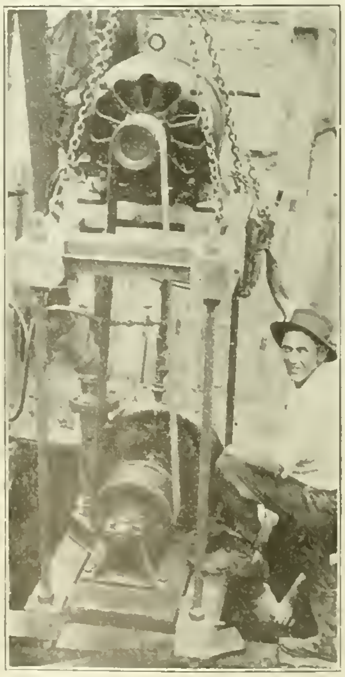
During the construction of the shut-off dam, by which the tidal flow in the Charles River was stopped so that an earth dam could be built, the rolling caisson gates of the lock were left open to afford additional waterway, as the velocity of the current made the work in the river exceedingly difficult. When the shut-off dam was completed, and it was desired to close the gates of the lock, it was found that the trackways, or recesses in the floor, were filled with sand, deposited there by the water, so that the gates could not be moved. The deposit in the upper trackway was partly removed by jetting, as the velocity of the current made it very difficult for a diver to work.

The apparatus for jetting consisted of a 2½-in. wrought iron pipe, with a header at the bottom end. In the header there were set six or eight nozzles of smaller pipe, flattened at the end to give long, narrow openings, and aimed downwards at an angle of about 30° with the horizontal. This apparatus was hung over the front end of the upper lock gate so as to bring the nozzles a little below the tops of the rails on which the gate runs. Connection was then made with the fire pump of a towboat, and water was forced out of the nozzles at a high velocity. Coincidentally, the lock gate was moved forward a few inches at a time.

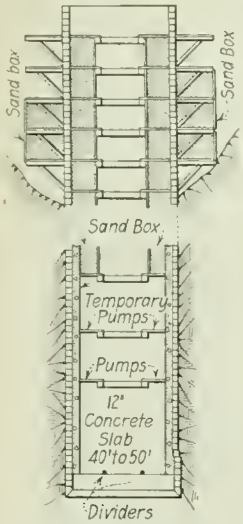
Progress was slow and finally ceased when about two-thirds of the distance across the lock had been traversed, as stones and other debris which had been buried in the sand accumulated ahead of the gate, the jets being able only to move them forward and not to raise them high enough so that they would be swept away by the river current. It was then necessary to resort to a diver, who completed the work, taking out the remaining material a bucketful at a time. The diver was assisted by a man who worked in the air chamber which surrounds the gate truck and which is reached by means of an air lock in the gate. As soon as the upper gate was closed there was slack water in the lock, and the work of cleaning out the lower gate trackway was an easy matter for the diver. —Edward C. Sherman in Journal, Boston Society of Civil Engineers.

AN EFFECTIVE PUMPING UNIT FOR EXCAVATION WORK.

In constructing the Bridge Street viaduct, Danville, Ill., the contractor, J. J. Jobst, of Peoria, Ill., used an exceedingly effective device for pumping water from excavations for the bridge piers. Although the pits were sheeted there were considerable quantities of water to be pumped during excavating operations, due to the porous character of the soil and to the proximity of the river. The accompanying illustration shows the pumping unit used on this work. It consists essentially of a 4-in. centrifugal pump mounted at the base of a timber and heavy rod frame, and a 10-hp. electric motor mounted at the top of the frame. Power is applied to the pump by means of a short section of belting. This pumping unit was suspended in the excavation, at any desired depth, by four chains, one attached near each upper corner of the frame. The ease with which this equipment could be moved about, and the fact that it could be suspended in an excavation at any depth, made it exceedingly effective on this work.



NOVELTIES IN DROP SHAFT SINKING METHODS IN WATER BEARING DRIFT.



In sinking drop shafts in Cuyuna iron ore district in Minnesota says a correspondent of the Engineering and Mining Journal outside hung sand box sinking weights and concrete wall stiffeners were used with success as shown by the accompanying sketch. By means of the outside sand boxes about 18 tons' weight per vertical foot was added to the shaft, and it was largely by the use of this additional weight that rapid progress was made. Besides providing extra weight, these exterior sand boxes supplied an easy means of shifting the weight on the shaft and thus keeping it plumb. As each sand box came into close proximity to the bottom of the pit, it was emptied and removed. Near the surface the shaft is held nearly perpendicular by excavating uniformly under the shoe and by digging under the high side when the movement of material outside the shaft has caused it to tilt out of plumb. But at greater depth this system has to be aided by the use of extra weight on the high side of the shaft. Rushes of sand and water often filled the shaft to a depth of 15 ft. or more, and usually at such times the shaft was thrown out of the perpendicular by several inches. In fact these rushes, or "boils" usually bowed the shaft or put a kink in it. A series of rushes so distorts many shafts of this type that they become useless except as exploratory shafts. To overcome this feature some means was sought to distribute the stresses developed, and a concrete slab along the end walls of the shaft was tried out with success. Upon final completion of the shaft this monolith of concrete can be either removed or left in place, depending on whether the extra space is desired inside the shaft.

METHOD OF MARKING MAIN HIGHWAY ROUTES IN NEW HAMPSHIRE.

Contributed by C. M. Brooks, Division Engineer, Highway Department, Keene, N. H.

Two years ago the Department in an endeavor to devise some scheme for perfecting the guide boards on the main roads through the State started the idea of banding telephone poles or, if there were no telephone poles, of banding trees or set posts, so that the general public following these bands could keep on one main road through the state. At that time only the four main trunk lines through the state were banded. The idea was to band three poles each side of an intersecting road with a band eleven inches wide with a 2-in. stripe at top and bottom. Information signs were placed at the State line and also at junction points to inform the public what these bands were for. The following is a general description of the four main Trunk Line roads and the colors in which they were banded. The West Side road, which extends from the Massachusetts State line south of Hinsdale through Keene, Newport, Lebanon, Hanover, Twin Mountain and Whitefield to Colebrook, was banded blue with a white border.

The Merrimack Valley road, which extends from the Massachusetts State line in Nashua through Manchester, Concord, Laconia, Plymouth and Franconia Notch to the West Side road at Twin Mountain, was banded green with a white border.

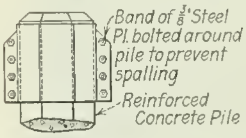
The East Side road, which extends from the Massachusetts State line in Seabrook, over the Ocean Boulevard in Hampton and Rye to Portsmouth, through Dover, Rochester, Tamworth, Jackson, Pinkham Notch, Gorham, Berlin and Dixville Notch to the West Side road at Colebrook, was banded yellow with a black border.

The South Side road, which extends from the Vermont State line near Bellows Falls, Vt., through Alstead and Acworth to the West Side road, north of Marlow, then follows the West Side road south to Keene, then through Dublin, Peterborough, Wilton and Milford to the Merrimack Valley road in Nashua, then follows the Merrimack Valley road north to Manchester, then through Candia, Raymond, Epping and Exeter to Portsmouth, was banded brown with a white border.

This system of marking these lines at once sprang into such favor that last year in connection with the banding, town line signs were placed. These town line signs gave the information "Town Line" and also the names of the two towns, the lettering on which, carried out the color scheme of the bands on the poles.

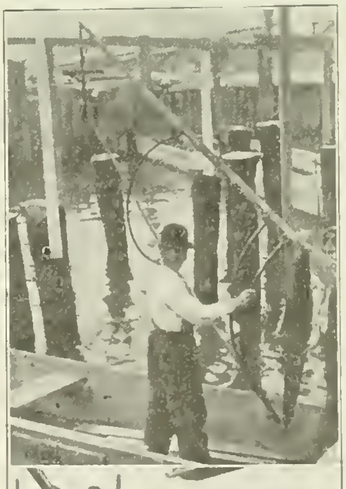
In 1916 further marked routes will be arranged. A map is issued showing each route in its selected color.

BANDING CONCRETE PILE TOPS TO PREVENT SPALLING.


Band of 3/8" Steel Pl. bolted around pile to prevent spalling
Reinforced Concrete Pile

The greatest difficulty in driving precast concrete piles is to prevent spalling or shattering of the tops by the hammer blows. A preventive device recently used with success is illustrated by the accompanying sketch. The two-part steel band was made of 3/8-in. plate 15-in. wide and was bolted tight around the pile head. In very hard driving this band was effective in preventing bad spalling. In using this band it was also found that a great aid against spalling was to prevent the driving block from becoming cupped. When cupped the shock of the blow came on the perimeter of the pile and scaled off the edges.

A DEVICE FOR SAWING OFF PILES UNDER WATER.



The device shown in Fig. 1 was used with success by Arthur C. Freeman, of Freeman & Agelasto, engineers, Norfolk, Va., in cutting off a large number of piles under water. The piles were cut off on a very flat grade from above water level to as great a depth as 40 ft. under water.

As shown in Fig. 1 the device consists of a cross-cut saw mounted at the end of a frame consisting of two long poles connected at their top and braced at lower points by curved rods as shown. The correct level for cutting off the piles is established, as shown in Fig. 2, by supporting a continuous line of timbers on struts resting on the projecting piles, and by bracing adjacent lines as shown. The top brace of the saw frame rests on this line of timbers, and is prevented from moving sidewise by knee-braces. The sawing of the pile is accomplished by a man who grasps the top brace and moves its end up and down. The saw is held against the pile by a rope playing against the side of the pile opposite to the curved braces (see Fig. 1).

METHOD AND COST OF CONSTRUCTING A PILE DRIVER BARGE.

Contributed by W. D. Jones, Assistant Engineer, Harbor Department, Los Angeles, Cal.

A barge was desired of sufficient size to carry a pile-driver and the equipment necessary to operate same when working in places more or less isolated from base of supplies. A barge 23 ft. 10 in. x 63 ft. was decided upon and provided sufficient space to carry the driver and a small repair outfit such as an anvil, forge and tools. A water tank of approximately 2,000 gal. capacity was provided in center of barge to supply boiler when work was removed from fresh water supply from pipes. As considerable towing was to be done with this barge one end was given a fairly long rake while the other was given a relatively short one in order to afford as much flotation as possible for the driver which was placed over this end. As sea worms are very active in Southern California waters a covering was placed over the bottom and sides to water line to prevent as much as possible their reaching the planking. This consisted of a coat of creosote and coal tar placed while hot on the planking, then a layer of ships felt over which was placed 1 in. redwood sheathing which was given a coat of hot coal tar and creosote. A flat slope at waters edge was selected for a site and the barge constructed resting on timbers and blocking high enough to permit men working underneath, and with sides parallel to waters edge. When completed timbers were laid under barge and into the water and greased at low tide. When tide came in the barge was lowered onto these skids and slid sidewise into the water. As constructed the barge has given excellent service. View 1 shows barge resting on blocking prior to placing the decking and View 2 shows the solid longitudinal bulkheads and water compartment. The cost of construction is summarized as follows:

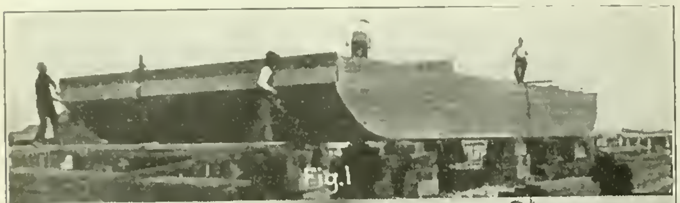


Fig.1

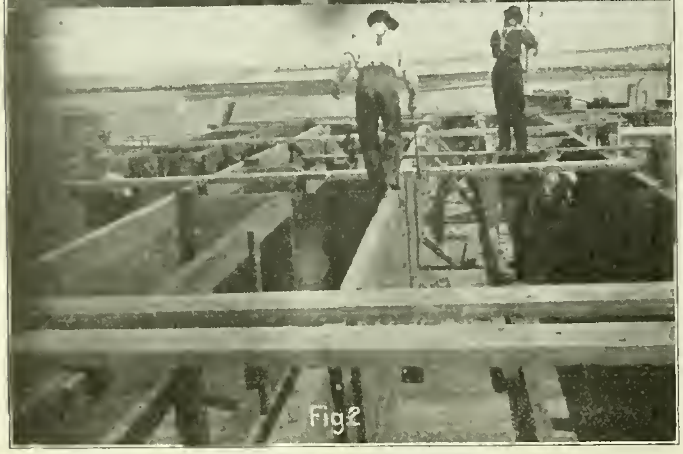


Fig.2

Classification.	Cost Labor.	 Equipment.	 Material.	Total.	Unit cost.
Handling material	$ 47.57			$ 47.57	
Moulds	4.86			4.86	
Framing	236.56	$15.00		251.56	
Planking	243.07	10.00		253.07	
Caulking	215.67			215.67	
Water compartment	36.05			36.05	
Guard rails	4.56			4.56	
Painting	9.87			9.87	
Launching	13.12			13.12	
Engineering	40.23			40.23	2.5%
Administration	30.90			30.90	1.9%
Lumber, 25,786 ft. B. M.			$504.40	504.40	$19.56 M.
Hardware and paint			183.58	183.58	
Totals	$882.46	$25.00	$687.98	$1,595.41	

Dimensions—63 ft. long, 24 ft. wide, 5½ ft. deep, 7,816 cu. ft.

Dimensions of tank—16½ ft. long, 4 ft. 8 in. wide, 3½ ft. deep, 7,000 gal. capacity, full.

Cost per 1,000 ft. B. M. of lumber in barge, complete, $62.

Cost per cubic foot of barge complete, 20.4 ct.

Total cost of barge complete in the water, $1,595.44.

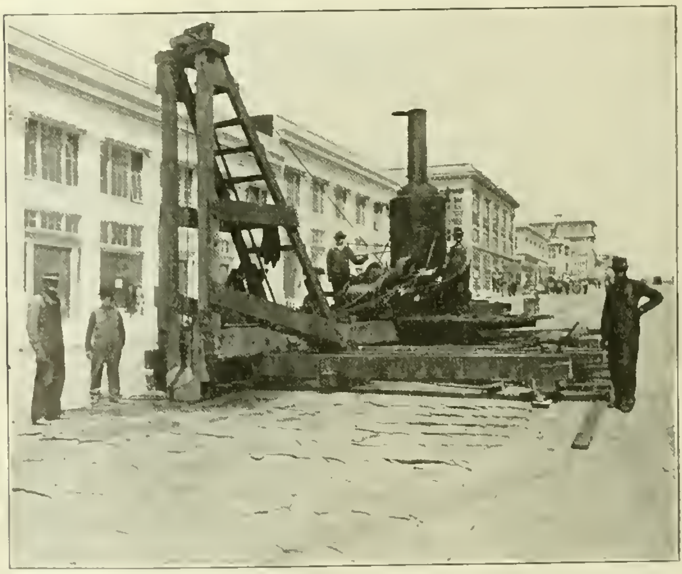
Wages paid per day: Foreman, $5; carpenters, $4; caulkers, $4; laborers, $3 and $2.50. Time consumed in constructing, 30 days.

BREAKING UP ASPHALT FOR NEW STREET RAILWAY CONSTRUCTION.

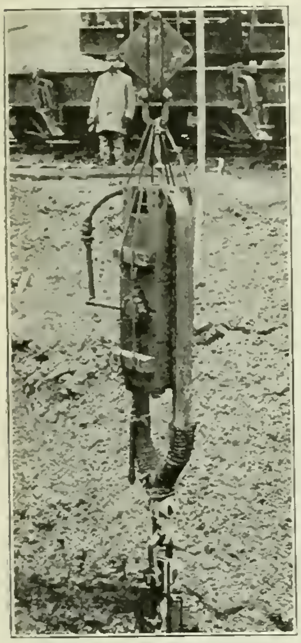
Contributed by E. G. Tilton, San Francisco, Cal.

A method of removing 3-in. asphalt pavement on concrete base in San Francisco is illustrated here. The first operation was the cutting of grooves through the 3 in. of asphalt surface. This was accomplished by means of a 14-ton gasoline road roller with a device fitted around the tread of one of its 6-ft. wheels. This device consisted of a cutter in four quadrants made of 3x⅝-in. tool steel bolted between angle-iron rims on each side, the angle-irons in their turn being secured by bolts through their bottom legs and the tread of the wheel. The cutter was forged down on one side chisel-fashion to a blunt edge. The angle-iron rims were curved to a full circle, but left open and were drawn tightly upon the wheel by means of tension bolts which passed through lugs riveted to their standings legs at the open ends. The roller was run at very slow speed over the pavement, following chalked line defining the side boundaries of the trench, and four cuts were made at the rate of about 300 lin. ft. of single cut per hour, its crew consisting of one engineer or runner. This machine, an invention of the contractor, was very effective and accomplished the work more expeditiously and economically than could be done by men with gads and striking hammers.

After a strip of asphalt had been grooved, the breaking up of it and its concrete base was proceeded with. This was effected with a 2,700-lb. pile hammer operated by a steam-driven, two-spool, donkey engine of 20-h.p. The driver was mounted on a frame supported on skids which in turn rested upon the ground. The frame at its rear end was pivoted to the skids which enabled it to be swung horizontally through a portion of an arc. The gins were about 16 ft. high and the hammer was generally dropped from 8 to 12 ft. Three blows were given and the gins were then swung about 3 ft. through the arc; no blows being made nearer than 1 ft. or 18 in. inside of the limiting groove in the asphalt surface. The gins are rotated by the engine by the agency of lines led to its spools and the driver was hauled back as required by the same method, the hauling line being made fast to a steel deadman stake driven in the center of the street at the far end of the block wherein work was being carried on. This method of breaking pavement, which was original with the contractor, was simple and far more expeditious and cheaper than that of breaking by hand with gads and hammers. The rate of progress was about 300 lin. ft. or 6,000 sq. ft. of surface in an 8-hour day with a crew of 1 engineman and 3 laborers and a foreman.



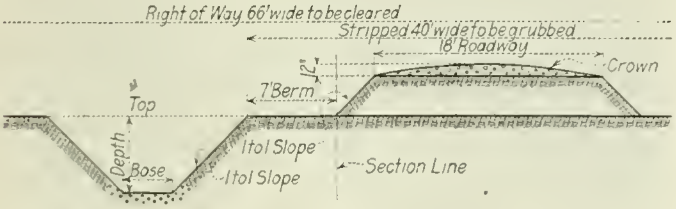
DRIVING SHEET PILES OUT OF THE GROUND.



Driving steel sheet piles into the ground is an ordinary process, but driving them out again is a process that is less familiar. The accompanying picture shows how in warehouse construction at Pittsburgh, Pa., the contractors, the McKelvey-Hine Co., drove out of the ground sheet piles previously driven 35 ft. into the ground. A steel yoke was tightly fitted around an inverted steam hammer and the whole arrangement was hung from a locomotive crane. At the bottom of the yoke was hung a shackle which was bolted to the top of the steel pile. A strain was then put on the line from the crane and the steam hammer was started. As the hammer drove the pile upward the crane maintained the gain and in a few minutes the pile was free. A No. 6 hammer weighing 2,900 lb. was used; the piston weighed 400 lb., and struck 75 blows per minute, using 25 cu. ft. of compressed air. Only an occasional pile was bent in pulling. This device permitted the salvage of piles which otherwise, owing to the cost of pulling, would have been left in the ground.

SPOILBANK HIGHWAYS ON MINNESOTA DRAINAGE DITCHES.

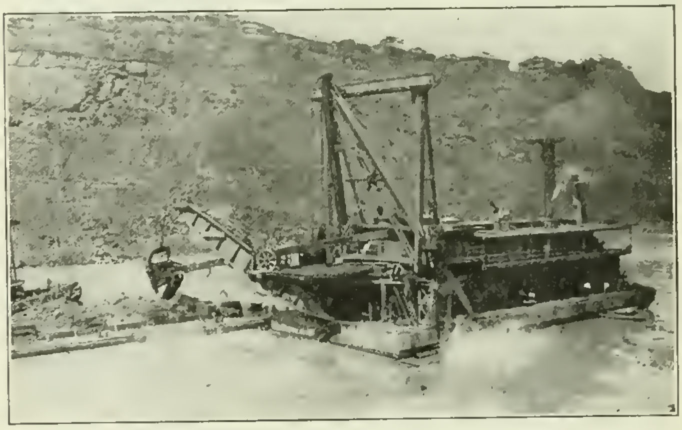
Standard drainage practice in Minnesota makes highways of all main ditch spoilbanks. The typical arrangement as worked out on Judicial Ditch No. 25, in Beltrami County is shown by the accompanying illustration. On this ditch there will be 223 miles of road construction. The drawing requires very little explanation. Briefly a strip 40 ft. wide on the spoilbank side of the ditch is thoroughly grubbed. The specified construction is in brief as follows: Material excavated from the ditches, except stumps, stones, roots and rubbish, shall be spread along the grubbed strip in a uniform manner, forming a roadway. The earth excavated from the upper part of the ditch shall be spread on the bottom of the roadway, and the firmer or harder material excavated from the bottom of the ditch, shall be placed on top of the roadway in such a manner as to form a working base for a good passable highway. Material must be spread according to the direction of the engineer, and if necessary, the engineer will set slope stakes along the grubbed strip, and all material will be confined within these slope stakes. The roadway shall be 18 ft. wide on top, with a crown of 12 in. This crown shall be continuous and free from sags, undulations and ruts. Unless impossible, because of weather or material conditions, the contractor will be required to level the roadway within 60 days after the passing of the ditching machine. After the roadway has been thoroughly shaped and crowned, the contractor shall use a road drag and proceed to fill all holes, cut down humps and overcome all wavy conditions.



THE DREDGE THAT MADE THE WORLD'S RECORD AT CULEBRA, PANAMA.

From midnight to midnight on Feb. 18, 1916, the 15-cu. yd. dipper dredge "Cascadas," shown here working in Gaillard (Culebra), Cut, Panama Canal, excavated 23,305 cu. yd. of rock and earth. This is believed to be the world's record. The official account of the performance is as follows:

Taking its weight at 3,000 lb. to the cubic yard (approximately 110 lb. to the cubic foot), the weight of the material dug by the "Cascadas" was approximately 35,000 tons. What is claimed to be the heaviest train ever hauled by one locomotive, from Baltimore to Philadelphia, consisting of 55 cars of coal, carried 4,102 tons. The output of the "Cascadas" on Feb. 18 weighed more than the contents of eight such trains. The displacement tonnage, or weight complete, of each of the latest battleships of the United States Navy, the "Idaho," "Mississippi," and "California," now under construction, is to be about 32,000 tons. The displacement tonnages of the "Missouri," "Ohio," and "Wisconsin," first line battleships eight years ago, which passed through the canal on the midshipmen's practice cruise of 1915, were 13,450, 13,900, and 12,830 tons, respectively, an aggregate of 40,180 tons.



The actual working time of the "Cascadas" having been 23 hours and 15 minutes during the record day, the rate of output was slightly over 1,002 cu. yd. an hour. This is about 1,500 tons an hour or 25 tons a minute. The "Cascadas" was built by the Bucyrus Co., South Milwaukee, Wis., and of her record the "Canal Record" says: The 15-yd. dipper dredge, "Cascadas," was placed in commission on Oct. 31, 1915, and was in the cut continuously until March 20, when she was brought to the repair dock at Paraiso for renewing the starboard spud. During that time, slightly over 4½ months, the "Cascadas" excavated 1,447,946.37 cu. yd. and was delayed by breakdowns 77 hours and 35 minutes. Her average excavation was 466.44 cu. yd. per hour, over a working period of 3,104 hours and 25 minutes. The dredge was engaged throughout in excavating rock. The loss of time from breakdowns was only 2.44 per cent of the total working time.

COMPARISON OF THE WEIGHT AND STRENGTH OF MANILA AND GALVANIZED WIRE HAWSERS.

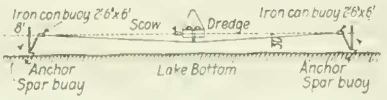
The following table gives a comparison of the weight and strength of several different sizes of Manila and galvanized wire hawsers:

Galvanized wire hawser, 6x37 in.		Manila hawser		Approximate strength, lb.
Diameter of wire, in.	Weight per 100 ft., lb.	Diameter of rope, in.	Weight per 100 ft., lb.	
2½	103	7½	168	44,000
2¾	120	8	192	52,000
3	158	9	243	63,000
3¼	177	10	300	76,000

It will be noted that, for the same breaking strength, a manila hawser must be approximately three times as large as a galvanized wire hawser. The data were compiled by the John A. Roebling's Sons Co., of Trenton, N. J.

AN UNDER-WATER ANCHOR LINE ARRANGEMENT FOR DEEP WATER DREDGING.

When dredges are anchored by lines run out from deck level tugs and scows cannot, on account of the lines, be freely handled alongside. The sketch shows a method of anchoring by means of submerged line used first, we believe, in building the Buffalo Breakwater. The dredge is fitted with a spud at the middle of each end; the spuds extend 10 or 12 ft. below the bottom of the hull and each has three sheaves, one fore and aft and two across hull. These sheaves are at the bottom of the spuds. On deck near each spud are three other sheaves. From the drum each anchor line extends over a dock sheave, down the side of the spud and under the spud sheaves and then out to the anchors. As many as six lines are near the dredge well under water and tugs or anchor lines can be used with this arrangement. All these scows can come alongside on all sides without interference.

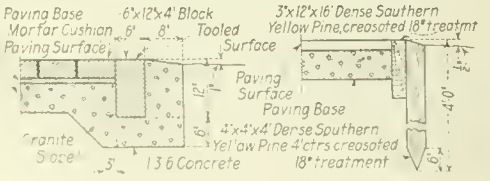


CEMENT BAG CLEANING PLANT.

Thorough cleaning of cement bags is an important economy for large users of cement. The Cleveland Railway Co., for example, has at one of its yards, in a separate building, a cleaning plant which, including building and machinery, cost about $2,500. The cleaning machine consists of a polygonal drum 12 ft. in diameter whose periphery is wire screen of 1-in. mesh. This drum is motor rotated 12 r.p.m. and in it the cement bags are placed and beaten about by the rotation until threshed clean of cement dust. The cement drops onto the floor or flies loose into the air, whence it is sucked by a small fan into a dust chamber where it settles. The bags are cleaned 500 to 1,000 at a time and two men can clean 1,000 bags per hour. About 700 lb. of cement is regained from 1,000 bags, or over seven bags of cement. This cement is rebagged and used. In addition saving is made of freight of 700 lb. on each 1,000 bags returned to the mills. Labor for cleaning amounts to 40 ct. per hour. Previous to the installation of this cleaning plant three men were employed whipping bags at a wage cost of $2,000 per year.

HEADER CONSTRUCTION FOR PAVEMENT IN HOUSTON, TEXAS.

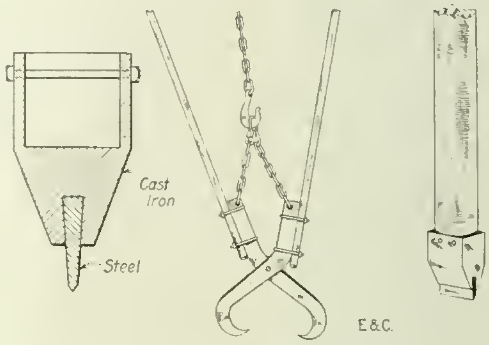
In the heavy clay soil of Houston, Tex., streets a pavement end does not stand up unless bulkheaded by a strong across-street header. In the accompanying drawings are shown two types of header construction developed to meet the conditions. The granite header is employed where the pavement ends permanently. It is a particularly sturdy design, the concrete base and abutment for the granite blocks being in one piece with the pavement base and drop end heavy enough to provide a strong across-street beam to take concentrated load. When paving is ended temporarily to be continued in the near future the creosoted timber header is used. Its construction requires no explanation besides the drawing. These headers are the design of Mr. E. E. Sands, City Engineer of Houston.



Granite Header Timber Header

DEVICES FOR "EXCAVATING" SUBMERGED TIMBERWORK.

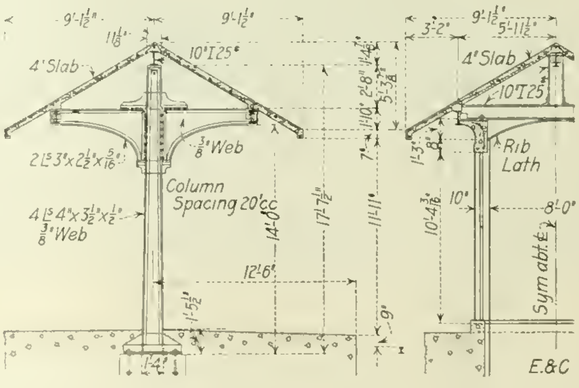
The sketch shows two useful devices employed for excavating through submerged and partly buried cribbing when encountered in founding a bridge pier or sea wall or in other moderately deep subaqueous construction. The chisel head fitted onto a pile is used to cut through the timbers; the pile with its chisel head is driven by pile driver as an actual pile is driven. When cut apart, the tongs are used to break loose and lift the timber. These tongs are manipulated by two long pole handles by men on a scow and when a "hold" is secured are hoisted by derrick. On the work where these devices were first used the chisel blade had a length of edge of 14 in., and projected $4\frac{1}{2}$ in. from the cast iron head, and both of these dimensions proved a little too small. The tongs were made of $\frac{5}{8}$x3-in. steel.



DETAILS OF AN EFFECTIVE TYPE OF ISLAND CANOPY AND SHELTER.

In connection with the new station of the Delaware, Lackawanna & Western R. R. at South Orange, N. J., a type of island canopy and shelter has been developed which is in keeping with the permanent character of the station proper.

The canopy consists of a 4-in. continuous reinforced concrete slab supported on three lines of 10-in. 25-lb. I-beams. The center line of beams rests on top of the plate-and-angle columns, the latter being spaced 20 ft. on centers. The two side lines of supporting I-beams, which are each spaced 5 ft. $11\frac{1}{2}$ in. from the column center, frame into brackets cantilevered from the columns. The canopy roof has a spread of 18 ft. 3 in., and its eaves are 11 ft. 11 in. above the platform curb or 12 ft. 8 in. above the top of rail. Details of this canopy are shown in Fig. 1.



Canopy Shelter

The same type and size of roof is used for the shelter as for the canopy, but it is supported in a different manner, since the line of columns is replaced by the walls of the shelter. These walls are double, with an air space between them, the clear width of the shelter being 8 ft. 0 in. The principal features and dimensions of this shelter are shown in Fig. 2.

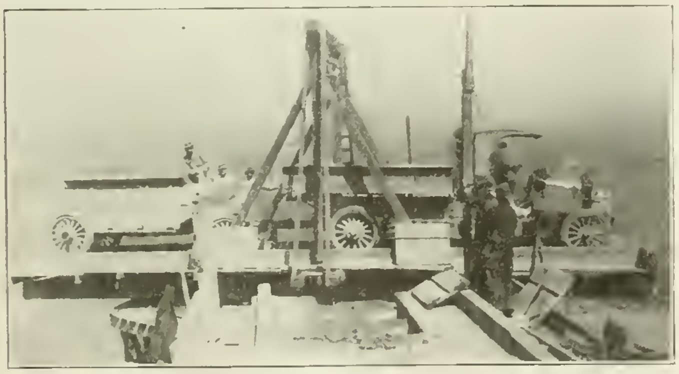
REMOVING EXCAVATED MATERIAL BY A TIPPLE.

In excavating the basements for the William Penn Hotel, Pittsburgh, Pa., the material was removed from the site in the following manner:

The material was excavated with a Thew steam shovel, equipped with a $\frac{7}{8}$-cu. yd. digging bucket. It was then loaded into Lakewood side-dumping cars of $1\frac{1}{2}$ cu. yd. capacity, these cars operating over a narrow-gage track to an elevating tipple located at the street side of the building site. This tipple, a view of which is shown in the accompanying illustration, was operated by a double-drum hoist, and was provided with two elevating cars of 5 cu. yd. capacity each. After being loaded directly from the side-dumping cars the material was elevated and dumped automatically into motor trucks of 4 cu. yd. capacity, each of which was fitted with a trailer of about the same capacity. The trailers, however, were used only on the day shifts, as the streets were comparatively clear of traffic at night and a much higher speed could be attained by the trucks, thus making the trailers of less value.

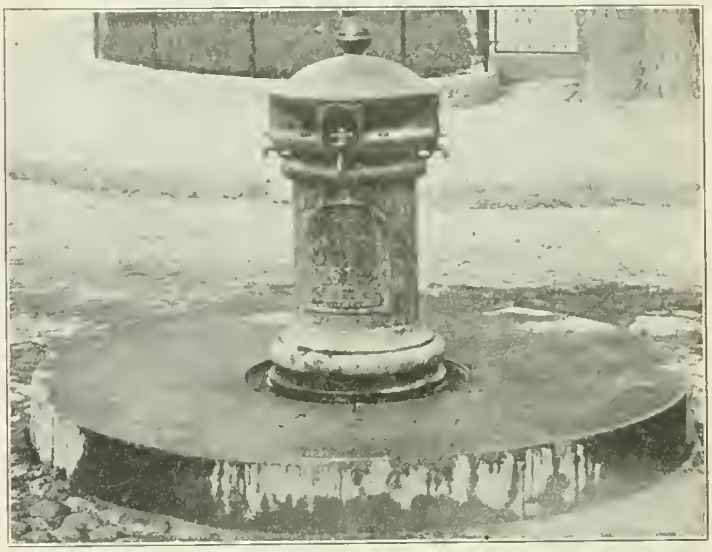
A TURNTABLE FOR EXCAVATED MATERIALS.

To expedite the disposal of excavated material from the site of the new William Penn Hotel in Pittsburgh, Pa., the contractor, the James L. Stuart Co., constructed the turntable shown in the accompanying illustration. This turntable was built at the unloading dock over the Allegheny River, an approach to it having been constructed of heavy planking, the portion adjacent to the turntable leading out over long steel I-beams. As shown in the view, this turntable was built of sufficient length to accommodate a Pierce-Arrow truck, having a dump body of 4 cu. yd. capacity and a trailer of about the same capacity. Underneath the turntable there were constructed three pockets of 5 cu. yd. capacity each, these pockets opening through gates, controlled pneumatically, into rows of $2\frac{1}{2}$-cu. yd. boxes placed on barges. The boxes were unloaded at the dumping site by a large floating derrick.



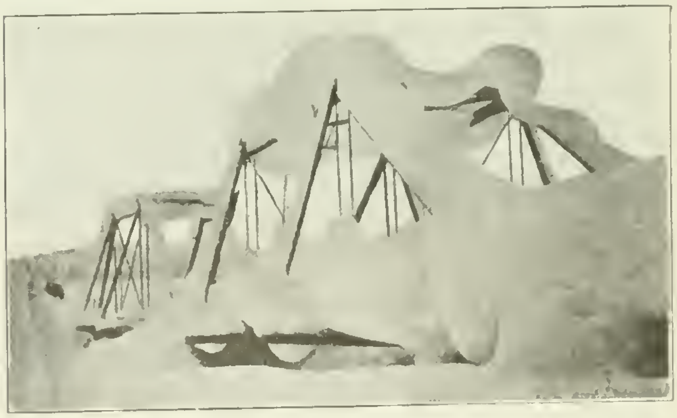
HORSE WATERING FOUNTAIN DESIGNED TO CHECK SPREAD OF GLANDERS.

A year or two ago the common horse drinking fountains were closed in the large cities of Massachusetts, on the requests of the State Commissioner of Animal Husbandry and local health boards. The request arose from the rapid spread of glanders, it being suspected that the common horse watering bowls were a contributing factor in the spread of the disease; consequently a fountain was devised that would serve horses through individual pails, supplied by the driver. In New Bedford most of the old fountains were of the horse bowl type known as the H. F. Jenks pattern. The bowls have been removed and new castings containing three or more self-closing faucets have been placed on the standard formerly supporting the horse bowl. This is designed to be a non-freezing device. The accompanying cut gives a good view of the remodeled fountain. This apparatus, as now maintained, is giving entire satisfaction to the community, particularly to the large owners of horses. Mr. R. C. P. Coggeshall is Superintendent of Water Works.



SNOW LOAD FOR HIGHWAY BRIDGES.

In many localities the snow load is not considered in designing highway bridges, and designers may easily get a misconception of its importance under conditions differing from those to which they are accustomed. For example, the snow load shown on the bridge in the accompanying view is a very important factor in its design. This view shows the Stewart Creek bridge on the Valdez-Fairbanks road, Alaska, the view being taken in January, 1914. The two 60-ft. spans shown are built of Alaska spruce.



The snow load varies according to climatic conditions; it may be zero, or in rare instances it may be as high as 60 lb. per square foot. Unpacked snow weighs from 5 to 12 lb. and packed snow from 15 to 45 lb. per cubic foot. Maj. F. A. Pope, Corps of Engineers, U. S. Army, recommends the following rules for determining the proper snow load, in pounds per square foot, for bridges not regularly cleaned of snow: Where a long series of weather observations is available, multiply the maximum observed annual snowfall in inches by 0.1. For bridge regularly cleaned, multiply the maximum recorded snowfall in inches for a single storm by 0.9.

A TROPICAL RATION LIST.

Contributed by R. C. Hardman, Colorado Springs, Colo.

Although ration lists have often been published, they have but rarely concerned themselves with the tropics. In going over some old papers recently the writer found a list of rations used some ten years ago in the Philippine Islands by the Bureau of Engineering, or Bureau of Public Works, as it is now called. These rations were for the use of reconnaissance parties, survey parties and construction camps. It will be noted that all the articles are such as can be well preserved under the extreme climatic conditions encountered in the tropics.

Provision.	Quantity.	Cost Unit.	 Total.
Pork sausage	6 cans	$0.225	$1.35
Beefsteak and onions	1 can	.325	.325
Corned beef hash	7 cans	.185	1.295
Compressed ham	2 cans	.26	.52
Beef stew	2 cans	.28	.56
Corned beef	2 cans	.275	.55
Mock turtle soup	2 cans	.27	.54
Bacon	4 lbs.	.20	.80
Flour	17 lbs.	.0405	.69
Corn meal	5 lbs.	.095	.475
Rolled oats	5 lbs.	.155	.775
Crackers, soda	4 lbs.	.14	.56
Bread, Boston brown	4 cans	.13	.52
Pork and beans	2 cans	.18	.36
Corn	4 cans	.165	.66
Succotash	4 cans	.18	.72
Potatoes	15 lbs.	.0235	.355
Onions	5 lbs.	.0295	.15
Peaches, evaporated	2 lbs.	.145	.29
Apples, evaporated	2 lbs.	.17	.34
Prunes	2 lbs.	.105	.21
Jam, blackberry	4 cans	.15	.60
Jam, strawberry	2 cans	.15	.30
Coffee	3½ lbs.	.27	.945
Tea, Early Breakfast	⅓ lb.	.40	.135
Sugar, granulated	10 lbs.	.079	.79
Cream, Highland con.	8 cans	.11	.88
Lard	5 lbs.	.16	.80
Baking powder	1 lb.	1.07	1.07
Pickles	1 qt.	.425	.425
Vinegar	1 qt.	.065	.065
Mustard, French	⅓ bot.	.205	.07
Salt	⅓ bot.	.18	.06
Pepper	⅓ box	.60	.20
Tomato catsup	2 pts.	.375	.75
Total			$18.60

The above rations were for one American for 30 days, and were ample for the time. In most localities it was possible to supplement this fare with chickens, eggs, fish, shrimps, crabs, frogs, and various native vegetables and fruits.

For Filipino "surveymen" the ration was three condensed milk cans full of rice per day with an occasional can of salmon when fresh fish could not be obtained.

COST OF REMOVING OLD CONCRETE PAVEMENT.

A length of 410 ft. of concrete pavement constructed in 1913 as a portion of what is known as the Byberry and Bensalem Service Test Road was in 1915 removed because of rapid wear and replaced by new concrete. The original pavement was 5 in. thick of 1:3:6 concrete. The amount of pavement removed was 792 sq. yd. or 110 cu. yd. It was removed by hand using bars and sledges. The cost of removal was 29.67 ct. per square yard or about $2.08 per cubic yard. The method and total cost of reconstruction were as follows: The subgrade was rerolled and tested by a template prior to the placing of the concrete. Upon this subgrade a concrete base 5 in. thick was laid. The concrete was prepared 1:3:6 and was mixed by Foote concrete mixer equipped with charging and discharging device. The surface of the concrete was struck with a template, which was guided at the side by steel channel sections. It was then floated with wooden floats, and roughened with a stiff broom when sufficiently set. Transverse contraction joints at right angles to the roadway were provided at intervals of 40 ft. These consisted of one thickness of tar paper. For the first 219 lin. ft. a mixture of 1½-in. Pottstown stone and ¾-in. pebbles was used, and for the remainder of the length a 1½-in. Pottstown stone was used. Pottstown grit was used throughout in place of gravel. After the concrete was placed, the road was closed to traffic. The concrete was covered with a ½ in. of grit and watered daily for seven days, at the end of which time the road was opened to traffic. Following is a detailed cost of this work:

Length of concrete, ft	410
Square yards of concrete	792
Cubic yards of concrete	110

	Total cost.	Cost per sq. yd.	Total cost per sq. yd.
Removing old concrete	$235.00	....	$0.2967
Preparation of sub-grade	52.75	....	.0666
Concrete base:			
484 bags of cement @ $0.36	174.24	$0.22	.....
68.85 tons of grit @ $1.43	98.46	.1243	.....
101 tons of stone @ $1.53	154.53 }	.2614	.....
36.7 tons of pebbles @ $1.43	52.48 }		
(Note.—Above costs include hauling to job by contract. One mile haul at 30 ct. per ton.)			
Labor and foreman	170.00	.2146	.8203
Total	$649.73	$0.8203	$1.1836

EFFECT OF BOILER STACK GASES ON STRENGTH OF CONCRETE.

Contributed by A. J. Becker, University of North Dakota, Grand Forks, N. D.

The purpose of an investigation recently completed at the University of North Dakota was to obtain some information relative to the strength of concrete after it had been exposed to the hot gases in the breeching over one of the boilers in the university power house. The temperature of the gases was about 600° F. Thirty 6-in. cubes were prepared of 1:2 concrete. The cement passed all the required tests and the sand was a clean, fairly sharp sand screened through a No. 10 screen from pit run sand and gravel. The pit is located near Melvin, Minn., in a beach deposit of the glacial Lake Agassiz. This material was part of a shipment intended for the usual building construction in the city of Grand Forks, N. D. Steel molds were used and all measurements were by volume. The quantity of water added was just sufficient to flush water to the surface when the concrete was spaded in the molds.

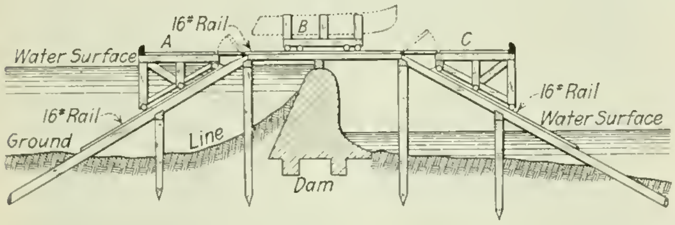
Three batches of ten cubes each were mixed, numbered 1, 2 and 3. When the specimens were six months old, six were selected from each batch, taken to the university power house, and placed in the breeching over one of the boilers. They were piled in an open checkerboard manner so that the hot gases on their way to the chimney played over them freely. At the end of two years' exposure in this manner, they were brought back to the testing laboratory and allowed to stand six months before they were tested.

The remaining twelve cubes were stored in a room whose temperature ranged from 60° to 90° during the year. The results of the tests are shown in Table I. The results are very uniform and show that there is a decided weakening of concrete exposed to the action of stack gases. No attempt was made to vary the length of exposure to the gases, because the number of specimens was limited and it was desired to make the results fairly conclusive under the assumed conditions.

	Strength in pounds Normal specimens.	 Exposed specimens.
Series No. 1	3,550	2,395
	3,780	2,540
	3,670	2,575
	.....	2,360
	.....	2,640
Average	3,668	2,502
Reduction in strength, 1,166 lb.; 31.8%.		
Series No. 2	4,220	2,410
	3,940	3,110
	3,340	2,480
	4,000	2,520
	.....	2,000
	.....	2,395
	.....	2,580
Average	3,875	2,499
Reduction in strength, 1,376 lb.; 35½%.		
Series No. 3	3,110	2,020
	3,000	2,220
	3,110	2,040
	3,220	2,060
Average	3,110	2,085
Reduction in strength, 1,025 lb.; 33%.		

MARINE RAILWAY PROPOSED FOR FOX RIVER.

The Rivers and Lakes Commission of Illinois recently published a report covering the survey and proposed improvement of the Fox River. Among other things navigation was reported upon and the Commission found that the river can be made navigable for small boats for the majority of its length at reasonable cost. There are numerous dams across the river and these could be passed, by small boats, by means of the type of marine railway here illustrated. The railway is of simple form and can be built at small cost. It would be modified to suit each dam.



Where there is a head race, the marine railway can be located at some distance down it and avoid the shallows generally occurring below the dam. In practically no case will the railway go directly over the dam, as shown in the illustration. In most cases the lift from the pool above the dam will be upon the bank at the end of the dam proper. Thence the car "B" will run on narrow-gage track to some suitable point below the dam where the boat will be lowered into the lower level. It will generally be necessary, excepting in a few cases where the head race can be utilized, to dredge a channel below the dam with a small pool into which boats will be lowered when going downstream, and vice versa going upstream. Where electric power is available, a small motor can be installed to operate the hoisting apparatus. This consists simply of a drum and cable with proper dogs and brake. Car "A" is hoisted and carrier "B" rolled off and on to car "C." Hook and cable are transferred to "C" previously and this car is lowered until the boat floats into the lower pool. Where electric power is not available, the hoisting drum can be worked by hand. At a majority of the dams electric power can be readily secured.

It is estimated that the cost of installing this marine railway for hand operation will be $700, and for electric operation $1,000. These estimates are for average conditions.

The river channel which would be prepared for use in connection with this marine railway would be 20x3 ft. minimum.

HOW TO MANUFACTURE GOOD REINFORCED CONCRETE FENCE POSTS.

Many miles of wire fencing on concrete posts have been placed during the last three years by the New York Board of Water Supply in connection with the Catskill Aqueduct construction. These fences were described by Ralph N. Wheeler in a paper before the New England Water Works Association.

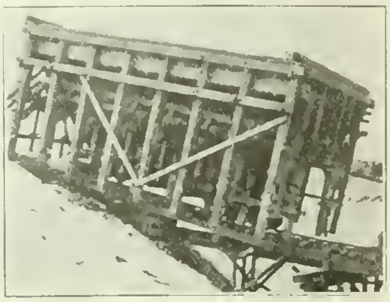
All posts were cast in thin sheet metal forms in horizontal position. The D or T sections were assembled by the battery or table method. The battery method employs a small steel car with hinged ends, so designed as to permit the placing and filling of five layers of six molds each; the table method makes use of a skeleton table on which the molds are placed. Both methods provide for tightly closing the ends of the molds. Preference is expressed for the table method, as the faces of posts are exposed for troweling or rubbing at the proper time. Slightly more floor area is, however, required. Objections to the battery method are the drip from the upper layers, which tends to pit the faces of posts below, and the impracticability of troweling or rubbing the faces. Joggling, essential for properly expelling the air, is accomplished by shaking the skeleton table or moving the battery car back and forward along its track. To secure good posts with either method the following points must be observed:

1. Molds should be coated with a thin film of oil.
2. Concrete aggregates should be of two sizes, well graded; the fine up to ¼ in., and the coarse from ¼ to ½ in. for the smaller sections of post and ¼ to ¾ in. for the larger.
3. The mixture must be very accurately proportioned, analyses being desirable to determine the exact proportions. Generally about one part of cement to three parts by volume of aggregates gave the best results.
4. The concrete must be thoroughly mixed and of wet consistency.
5. The ends of molds must be sealed tightly with clay, plaster of Paris, or cement, to insure good tops.
6. The air must be expelled by joggling and running a trowel back and forth through the mixture and along the sides of the mold while placing.
7. The reinforcement must be placed in correct position. This can be accomplished without a spacing device after a workman becomes skilled.
8. The reinforcing metal, particularly round wires, should be thoroughly rusted or nicked to give a proper bond. Bending the ends of these wires back 180° gives good results. As received from the mill, these wires are greasy from the drawing process, and it is necessary to hasten rusting by the use of a weak acid afterward neutralized. Posts tested to failure show that unrusted straight wires pull through, whereas properly rusted ones, or those with ends bent, break. It has been suggested that running the wire through a barbing machine such as is used in the manufacture of barbed wire nails would deform it sufficiently to give a good bond. This would add not over ½ ct. per pound to the cost.
9. Posts must be properly cured. They can be removed from the molds in 36 hours, and may be stood in a vertical position and water sprayed over them from suitably arranged piping, or preferably they may be spaced in a horizontal position and covered with sand or sawdust kept wet. Curing should cover at least two weeks, and better four.

10. The rounding of edges of the exposed face can be accomplished in the form, but better by rubbing with a carborundum brick after erection and before the wire is stretched. If fencing is attached by wrapping wires, rough edges assist in holding the wires.

Number and Compensation of City Managers.—On the first of January of this year 73 cities and towns in the United States had city managers. The combined population of these cities was 818,000. Of these cities 32 had less than 5,000 population, 18 between 5,000 and 10,000, and 23 had populations in excess of 10,000 each. The average salary of 36 of these city managers is $2,900 per annum.

MOVING A 60-TON SAND BIN BY GONDOLA CAR.

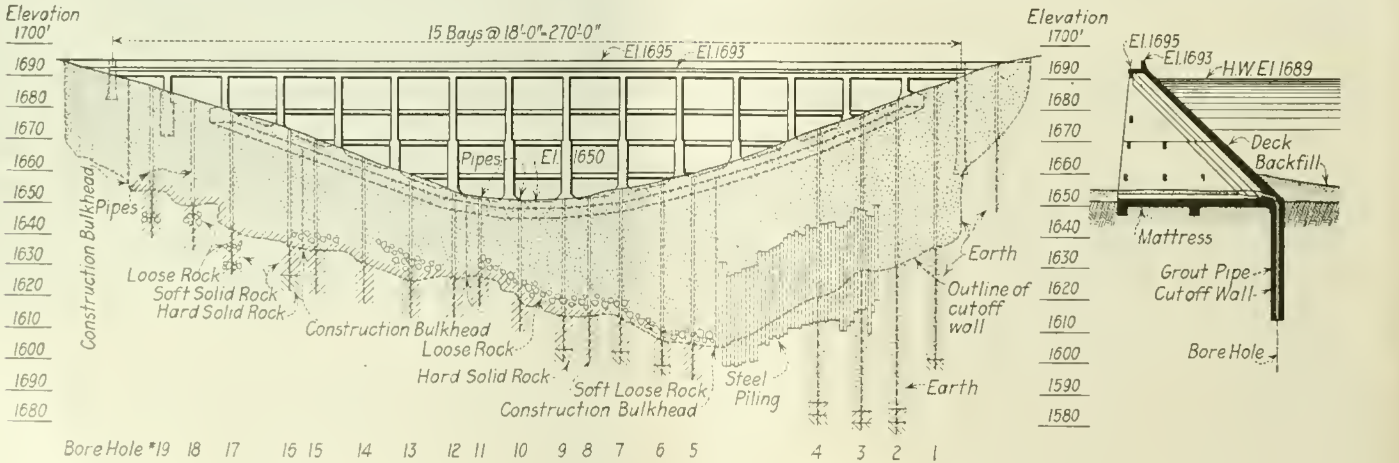


The bin illustrated originally stood astride a construction track at Lock No. 2 of the new Welland Canal, Canada. It was 30 ft. long, 30 ft. wide and 30 ft. high, weighed about 60 tons empty and held 250 cu. yd. of sand, and the same amount of broken stone. In the course of construction it became desirable to move the bin to a location 1,000 ft. distant and 30 ft. lower than its original position. From the construction railway an incline track was laid down the bank and out onto a trestle at the end of which was the desired new location of the bin. The bin was jacked up 2 ft. and a 60-ton gondola car was run underneath it. Then timbers were laid across the top of the car and the bin was lowered onto them and securely lashed to the car. Racking cables and inclined struts were placed where needed. A 45-ton locomotive hauled the car and bin along the construction track to the point where the switch down the bank and onto the trestle led off from the main track. Here dead men were set and two tackle blocks fastened to them; the combined capacity of the blocks was 80 tons. Through each block a line was run with one end attached to the car and the other end passing to a locomotive on the construction track. To lower the car the two locomotives were backed toward each other. Including all preparations, it required 1½ days to lower the car into postion on the trestle. The bin was then jacked up and the car pulled from under. The contractors for the work and by whom the bin was moved, are Belding, Yerburgh & Hutchinson.

DAM CUTOFF WALL WITH INSERTED GROUT PIPES.

Contributed by Eugene Lauchli, Civil and Hydraulic Engineer, New York, N. Y.

The cutoff wall, as illustrated, is 3 to 3/5 ft. thick and 30 to 57 ft. deep. The materials encountered during excavation were such that little reliance could be laid upon it as a barrier against water under pressure, and an endeavor was made to carry the cutoff wall down to solid rock. One wooden derrick with a 60-ft. boom and a steel derrick with a 100-ft. boom handled the materials excavated from the cutoff trench. Excavation was done with picks and shovels, no blasting being required. The sides of the trench stood well, requiring no bracing or sheeting, even when 57 ft. deep; however no chance was taken, and enough bracing was provided to protect the crews against a possible cave-in. After rock had been reached, drills were put to work in order to ascertain the nature of the underlying rock. Except in a few instances, soft solid rock was encountered, same disintegrating rapidly when exposed. All bore holes, except holes No. 8, 9, 10, 11 and 20, were carried down with machine drills, the others being churned drilled. After holes No. 7 and 8 had been put down, it was feared that no rock could be found except at great depth, thus necessitating much excavation and concrete fill, and an attempt was made to drive steel sheet piling, as shown. The result thus obtained can hardly be called successful, and only about 50 lin. ft. of piling were driven. It was then decided to provide all test holes with grout pipes, extending these to the surface of the ground, on the downstream side of the deck and to grout these under pressure, should leaks develop with the reservoir full. The cut-off wall was concreted in sections, between wooden bulkheads, the abutting surfaces of the concrete sections being tongued and grooved. A 1:3:6 mixture was used, man-size stones being embedded in it.



Elevation

Cross Section

LOWERING 550 FT. OF 10-IN. WATER MAIN UNDER 60-LB. PRESSURE.

Contributed by John E. Weyher, Superintendent of Water Works, Kinston, N. C.

In order to do some asphalt paving on North Queen Street in the city of Kinston, N. C., it was necessary to do considerable excavating to adjust the street to the proper grade. Before the grading could be completed it was necessary to lower 550 ft. of 10-in. water main running from the bottom to the top of a hill about 25 ft. high. There were two vertical curves on the main, making it very difficult to lower. I was instructed by the Board of Aldermen to lower the main, if possible, without turning off the water in a single service. Procedure was as follows:

I employed twelve good laborers and had the dirt removed from the mains; then I staked off the ditch so as to leave a pillar of dirt 24 in. wide to extend across the ditch. These pillars of dirt were left near each pipe joint at such a position as not to interfere with caulking the joint. One pillar was left to each section of the pipe. The dirt was excavated from under the mains between the pillars (the ditch being wide enough for a man to work on either side of the pipe). I then placed a man between each pillar upon which the mains were resting and had him gradually undermine the pillars. While the pillars were being dug away I was constantly walking up and down the main to prevent the men from removing the pillars too fast. The mains went down nicely without a single mishap. Some of the joints were leaking very slightly and these were recaulked. Some sections of this main were lowered as much as 5 ft. There was a 60-lb. pressure on while the pipe was being lowered.

Not a single service was interrupted. I was told before I undertook to lower the pipe that one of the commissioners and an engineer stated they could not see how it could be lowered under the conditions without turning off the water pressure.

MELTING SNOW WITH ASPHALT ROAD HEATER.

Contributed by Frank C. Perkins, Buffalo, N. Y.

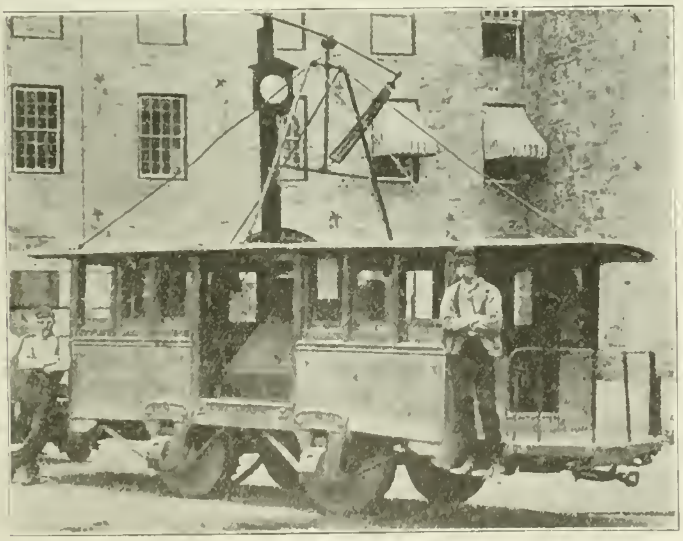
The accompanying illustration shows the novel use of an asphalt road heater for melting snow in Glencoe, Ill. The heater was used by Jno. A. McGarry & Co. of Chicago. It is an 8-ton roller (Iroquois) converted to the use described by the Barbour Asphalt Co. The large flue was built on to carry the flue gases over the top and down to the 5x7-ft. hood.

It may be stated that a 4-in. snow fall covered up the last 5,400 sq. yd. of a 63,000 sq. yd. penetration job and the heater was used to melt the snow from the 2 in. of top stone already spread on the concrete base. The cost of the snow removal was as follows:

Removal of heavy part of snow by hand	$ 17.00
Rent of heater 4 days at $20 per day	80.00
Engineer at $6.50 per day, including car fare	26.00
Helper at $3.50 per day, including car fare	14.00
Pocahontas coal at $6.25 a ton, delivered, at ½ ton per day	12.50
On 5,400 yd.	$149.50

This amounts to nearly 3 ct. per yard for melting alone. The actual pouring was also retarded about 50 per cent as it had to be done close behind the heater and the stone screening for the top also had to be heated. The writer is indebted to J. T. Child for the accompanying photograph and data.

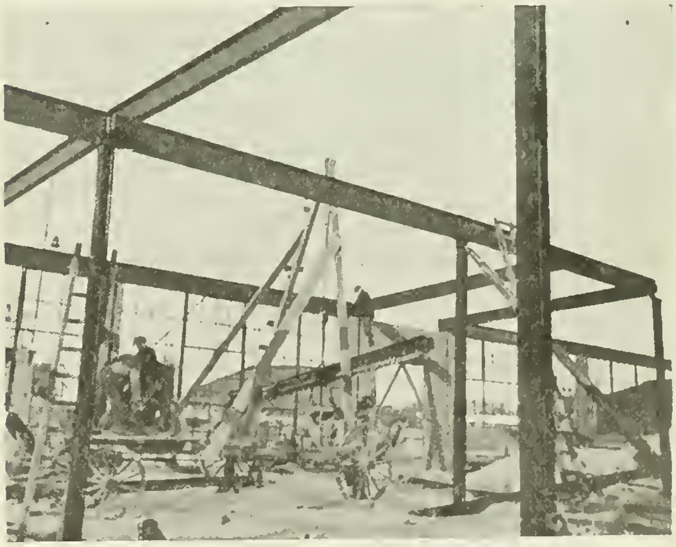
THE ELECTRIC FREIGHT LOCOMOTIVE AT ITS BEGINNING.



For fifteen months from July, 1888, to October, 1889, there was operated daily, except for three months in the winter, an electric motor car hauling freight cars 2½ miles from the factories at Ansonia, Conn., to the wharves at lower Derby, Conn. Then came the discovery that the profit from electric transportation lay in passenger service and all energies of the electrical engineer were devoted to perfecting means for electric transportation of passengers. The occasional attempts in the meantime toward electric locomotives for freight service were regarded by the public as experiments in a new field. In one sense they, of course, were experiments but not in the sense that the idea of electric propulsion for freight service grew out of the success of electric propulsion for passenger service. As said above the fact was exactly contrary. In the accompanying picture is shown the little Ansonia-Derby electric freight locomotive which was put in operation now almost exactly 25 years ago. Perhaps justice is served better by designating this motor car the Van Depoele locomotive, from its designer, Charles J. Van Depoele. In comparison the modern electric freight locomotive is a monster. Van Depoele's locomotive weighed 17½ tons, its motor developed 75 HP., and it could haul a load of 35 tons. The latest electric locomotive of the New York, New Haven & Hartford R. R. weighs 220 tons, develops 2,800 HP. and hauls a load of 4,000 tons. These figures and our illustration are taken from an interesting article in "Aera" for April.

A SIMPLE FORM OF PORTABLE STEEL-ERECTION EQUIPMENT FOR MILL BUILDINGS.

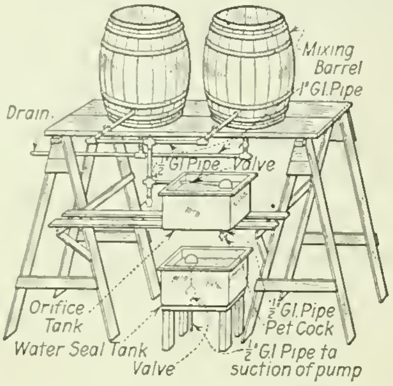
The accompanying illustration shows the effective erection equipment devised by E. F. Rockwood, chief engineer, New England Concrete Construction Co., Boston, Mass., to erect the steelwork for a weave shed. It consists of two pairs of wheels and their axles supporting a frame platform on which there is mounted a winch and A-frame. The A-frame is placed over the rear axle, the latter being 12 ft. long, and it is braced to the supporting frame in a manner which permits it to be tipped down when necessary to clear steelwork already erected. The hand winch is mounted at the front of the platform. This elongated wagon was fitted with shafts, although it was found that it was cheaper and more convenient to use workmen to move it about.



The principal features of the construction job on which this equipment was found so effective were as follows: The weave shed was about 120 ft. x 420 ft. The first floor of this shed is of pine plank supported by steel beams and girders resting on brick piers. The beams are 15-in. 42-lb. I-beams of 26-ft. span and 8-ft. spacing, and each girder consists of two 18-in. 55-lb. I-beams of 24-ft. span. The tops of the beams are about 8 ft. above the ground, which had been filled with cinders to a grade approximately level. There are about 240 tons of steel in this floor. By means of this equipment the steelwork was erected at a considerable saving over that represented by the bids of several steel erectors.

AN EMERGENCY HYPOCHLORITE PLANT.

The emergency hypochlorite plant used by the Maryland State Department of Health for disinfecting water supplies is here illustrated and described. Only ordinary and easily obtainable materials are used in making this plant—such materials as are readily available in any city having a public water supply. In fact the sketch here shown, with a bill of materials, is usually sent ahead to Maryland cities where the emergency exists, so that the requisite material will be on hand when the engineer from the Department of Health arrives. The apparatus has proven its value on many occasions. That it is serviceable is shown by the fact that several installations in Maryland are still in operation, a year or more after being installed.



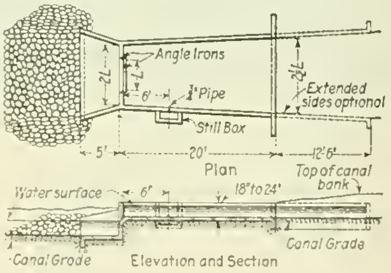
Bill of Material.—Following is a list of the materials required:

2 clean water-tight barrels.
Several feet of 1-in. and ½-in. galvanized iron pipe and tools for cutting and threading.
5 1-in. valves.
4 1-in. "T" branches.
1 1-in. by ½-in. cross or 4-way fitting.
4 locknuts to attach 1-in. pipe to barrels.
1 1-in. cross or 4-way fitting.
4 1-in. pipe plugs.
1 ½-in. pipe plug.
1 ½-in. petcock.
1 water tight tank, preferably lead lined, with valve and float control, which opens valve as water level drops. An apparatus of this type easily obtained is a flush tank for a toilet.
1 lead-lined watertight tank with valve and float control which closes valve as water level drops. This is necessary only where disinfectant is introduced into suction of pump.

This information was furnished by Mr. Robert B. Morse, Chief Engineer of the Maryland State Department of Health.

A NEW IRRIGATION WEIR BOX.

The drawing shows a weir box which is self-cleaning, requires no lowering or elevation of the canal grade or banks for installation, can be built and installed by any water user, is practically accurate and is not patented. The design of this box is based on extensive experiments conducted by V. M. Cone, Irrigation Engineer, U. S. Department of Agriculture. As shown, the weir has a rectangular notch formed by steel angles. It has, however, no bottom contraction, the crest of the weir being flush with the weir box floor, which must be level and which must not be greatly out of horizontal plane with the bottom of the approach channel. Also the weir box must be placed in the center of the ditch so that the water may enter it in a straight line. The still box is set to one side of the weir box so as not to obstruct free flow of water; it should be 1x1½ or 2 ft. and deep enough to provide a sand trap below the pipe entrance. Compared with a full contraction weir, the weir illustrated is completely self-cleaning, is only one-fourth as deep, is less in width and costs less to build of either timber or of concrete.

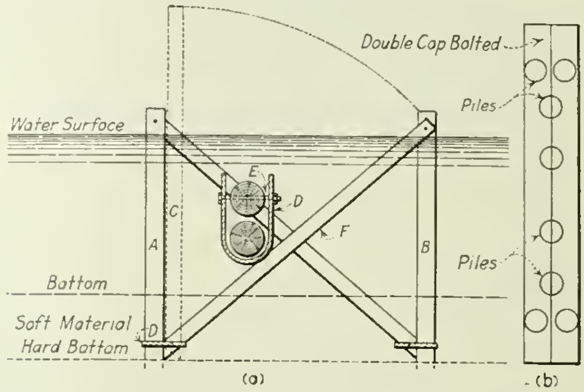


METHOD OF BRACING PILES BELOW WATER LEVEL.

Contributed by W. J. D. Reed-Lewis, Le Pas, Manitoba, Can.

The following method of bracing piles below the water level will, with limitations, be found useful in practice:

Referring to Fig. 1 (a) let A and B represent the bents of a trestle which it is desired to brace diagonally; let D represent a clevis (formed of a round or flat iron bar), with eyes for the bolt E; and F represent position No. 2 and C position No. 1 of the diagonal brace. It will be noted that the clevis can be bolted to the brace, then slipped over the head of the pile, worked down to a position near the bottom of the pile, and finally cramped over to its final position F.



By a modification of the usual plan of placing piles in a bent, as shown in Fig. 1 (b), sway bracing can be placed in a similar manner.

COST OF OPERATING A FORD CAR IN COUNTY ROAD SUPERVISION.

Contributed by C. V. Carpenter, Engineer Dickinson County Road Commission, Iron Mountain, Mich.

The car is owned by the Dickinson County, Michigan, Road Commissioners and was operated in their service from May 7, 1913, to Jan. 1, 1916. The investment statement is as follows:

First cost	$625.00
Extra equipment and tools	39.85
Equipment and tools for 1914	36.04
Equipment and tools for 1915	14.25
Total invested	$715.14
Depreciation first year	$194.25
Depreciation second year	285.94
Depreciation third year	84.95
Present value	150.00
Total invested	$715.14

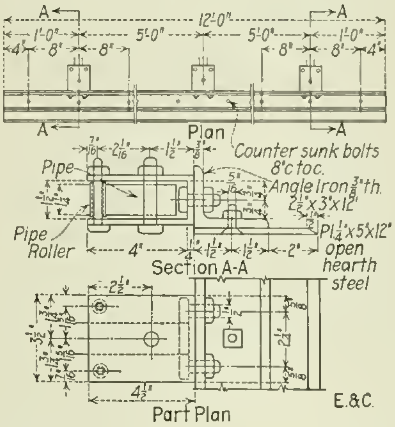
The depreciation for the first two years is the trade-in value offered by the local Ford agency. The present value is an arbitrary one set by the commission's engineer. No taxes were paid but the state license fee is included under equipment and tools. The operating costs for the period of service were as given by Table I. No garage or storage charges are included nor is the time spent in making repairs by the engineer. A total of 12.9 miles per gallon of gasoline was made: Prestolite tank in 1913 and 14; tank and magneto in 1915.

TABLE I.—COST OF OPERATING FORD CAR IN COUNTY ROAD WORK.

	Cost per mile			Total for three years, 50,168 miles		
	Miles, 12,000	Miles, 20,843	Miles, 17,325			
Year.	1913.	1914.	1915.	Total.	Per mile.	Pct.
Interest at 6% of investment	$0.0022	$0.0020	$0.0025	$ 111.54	$0.0022	$0.0366
Depreciation	.0162	.0137	.0049	565.84	.0113	.1797
Wear-outs and replacements	.0084	.0189	.0168	787.86	.0157	.2510
Gasoline, 3,889 gal. at 15.1 ct.	.0121	.0107	.0125	586.60	.0117	.1861
Tires	.0189	.0188	.0135	854.64	.0170	.2707
Oil, grease, waste	.0020	.0033	.0025	131.18	.0026	.0414
Lights	.0023	.0023	.0022	112.48	.0022	.0350
Total	$0.0621	$0.0697	$0.0549	$3,150.15	$0.0627	$0.9999

AN IRRIGATION CANAL SLOPE TRIMMER.

Concrete lining irrigation canals require smooth, evenly trimmed earth slopes. Generally this trimming is done by men with shovels working to stretched lines or straight edges. This is a labor consuming process and to reduce labor cost the U. S. Reclamation Service Engineers of the Carlsbad Project have substituted for the shovel a hand-operated slope trimmer of the construction shown by the accompanying drawing. The device, as will be seen, is a three-handled push knife 12 ft. long. The handles are 1¼-in. pipe. The practice is to set to exact slope down the bank and 10 ft. apart 1¼-in. Tee girders. The trimmer is set on these tee tracks at the top of the slope and pushed by the handles down slope, thus shaving the earth to exact plane between tees or girders. It is asserted that this trimmer showed considerable saving in labor compared with men using shovels.



COST OF PLANTING SMALL TREES AT KENSICO RESERVOIR.

The city of New York has planted over 800 acres on the marginal strip around Kensico Reservoir, during the past four years, with white, red and Scotch pine and Norway spruce. The cost of planting was given by Wilson Fitch Smith, of the Board of Water Supply, in a discussion before the New England Water Works Association. Three-year-old transplants obtained from various nurseries were planted in rows 6 ft. apart each way. During these two years, 551,000 trees were planted at an average cost of $12.38 per 1,000. The cost includes the following:

	Average for two years per thousand.
Cost of three-year-old transplants	$ 4.41
Freight on transplants	.43
Labor handling for inspection, and teaming	.50
Labor planting	6.30
Engineering supervision	.74
	$12.38

The labor was at the rate of $2 a day for an eight-hour day. These figures are the averages for two years' work. Toward the end of each season the men became more experienced, and planted about 500 trees per man-day.

METHOD OF HANDLING BULK CEMENT IN CONCRETE ROAD CONSTRUCTION.

In constructing some five miles of 16-ft. wide two-course concrete road in Lake County, Ohio, all cement used was shipped from the mills in bulk. The method of handling this cement on the work is described by H. P. Cummings, County Surveyor, as follows: Cement tight wagon boxes are used. These are placed so that top of box will be level with car floor. An 8-ft. coal chute is then hooked onto the planking across the car door opening, with the end resting in the wagon box. The cement is then shoveled into the chute until the car is cleared from door to door over a space about the width of the door opening. After this opening is made in the car, a low-hung open end cart is used, the body of which holds five sacks of cement. One man handles the cart, loading it by driving the open end into the cement and completing the filling with about three strokes of a winged hoe. He then wheels it to the wagon over a platform spanning the opening between car and wagon, and dumps it. On the line of the work, six boxes are used for receiving the cement. These boxes are fitted with a movable ridge pole to support a canvas cover which thoroughly protects the cement from storm. The cement is shoveled from the wagon into coal chutes hooked over the wagon box with the end resting in the receiving box. Each box is filled to a fixed point which furnishes just enough cement for a given length of pavement. The cement is shoveled from the receiving boxes into measured wheel barrows and wheeled to the mixer. The handling of cement in bulk proved very satisfactory. There was less waste than with sacks. Absolutely no cement was damaged by storms. The inspector could check the amount of cement used more easily than with sacks. And the contractor had no sacks to bother with and no money tied up in sacks.

EMPHASIZING THE FINISHING PROCESS IN CONCRETE PAVING.

To put one-third of the labor cost of laying concrete pavement into finishing is the practice at Sioux City, Iowa. As described by City Engineer T. H. Johnson the finishing methods are:

Following immediately, and keeping within a few feet of the levelers, is a man with a wood float 14x16-in., made of 2-in. oak plank, and having a handle 8 ft. long made of ¾-in. gas pipe. He goes twice over the entire surface. These floatings depress the pieces of coarse aggregate, and bring a flat face of the upper pieces parallel to the surface of the pavement. Also all inequalities of the surface are removed and a true crown established, the weight of the float being such that considerable portions of the concrete may be pushed or pulled around in the process of leveling. This heavy float compresses the concrete, as is shown by the quantity of water brought to the surface, and increases the density of the slab to the extent of the water removed, and, further, reduces to the same extent the future absorptive powers of the slab, which is the real benefit conferred. Following this is applied a dry mixture of 1 part cement and 1 part fine aggregate, in sufficient quantity to absorb all free water. This dry mixture does a number of very helpful things. For instance, it takes about 4 cu. ft. of water to mix an ordinarily wet yard of concrete, only about half of this water being used in hydrating the cement, the other half remaining in the concrete as free water. In other words, 7½ per cent of the total volume is free water, and if left there to evaporate there would result voids equal to 7½ per cent of the mass. The first floatings remove a portion of this free water and so close up the structure of the concrete that subsequent evaporation is materially discouraged. The dry mixture completes the removal of this free water, as is shown by the immediate stiffening of the concrete so that the balance of the finishing is done directly from its surface, without disturbing it a particle. It also furnishes enough mortar for properly finishing the surface. Being a rich mixture, it counteracts the effects of dust, dirt and other impurities brought to the surface by the water, and effectually seals all the pores in the pavement, preventing evaporation, and affording a hard, tough, dense, impervious skin coat for the surface of the pavement. After this dry mixture is applied, it is floated until thoroughly incorporated with the surface of the concrete. Subsequent floatings follow at short intervals as long as any moisture is brought to the surface. When the mortar begins to stick to the floats, and is slightly drawn after them, which is usually at about the seventh floating, the floating is discontinued. This leaves the surface rough, and it quickly sets with a hard, flinty glaze. This roughness of the final floating is frequently perceptible after two years of wear. Floats, made of 2-in. seasoned oak, are worn out and have to be replaced in two days.

General Civil Engineering Articles

REPAIRING SPLIT AND CORRODED PIPE WITH AN OXY-ACETYLENE WELDER.

One of the most recent applications of the oxy-acetylene welding process is to the repair of burst and split steel and iron pipe. This application is of particular interest to contractors, construction engineers, and water works superintendents, because of the fact that defective pipes can be repaired at considerable less cost than that involved in replacement.

Figure 1 shows a section of $\frac{3}{4}$-in. iron pipe which was split by freezing, and the same pipe as repaired by a welding equipment. Work of this character can be done at the rate of approximately 15 ft. of welding per hour at a total cost including labor, gas and material of from 75 to 80 ct. per hour. Where only short welds are to be made to repair small breaks the cost is practically negligible.

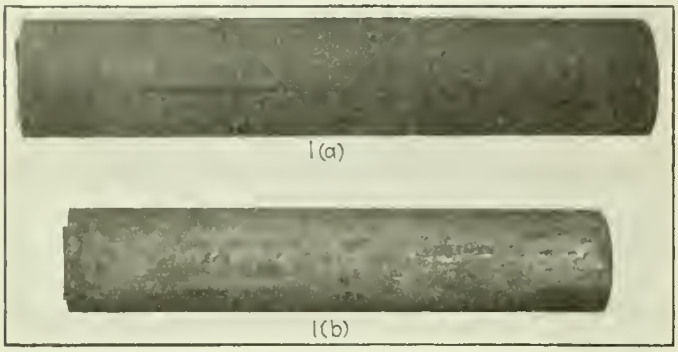


Fig. 1—(a) Section of $\frac{3}{4}$-in. Iron Pipe Split by Freezing. (b) Same Pipe Repaired by Oxy-Acetylene Welding.

The fact that welding of this character makes the pipe in every respect as strong as new pipe and that the work can be done while the pipe still is in place, makes this process of very great advantage to all who have occasion to use pipe to any great extent.

Figure 2 shows a very badly corroded pipe in the three stages of repair. The two large holes in the pipe are welded up and considerable new material has been added to the body of the pipe to fill in the defective spots. Figure 2a shows the pipe before any work had been done on it; 2b shows the pipe immediately after the welding work was done; and 2c shows the pipe after it was machined. Of course this machining adds nothing to the strength of the pipe, although it contributes to the appearance. It does show, however, that pipe even in this bad condition can be repaired and put into perfect shape by this process. The time required to do this work on the piece illustrated (section of 6-in. pipe, 16 in. long) was approximately one hour, including machining. The cost, including labor, but not including machining, was approximately 80 ct.

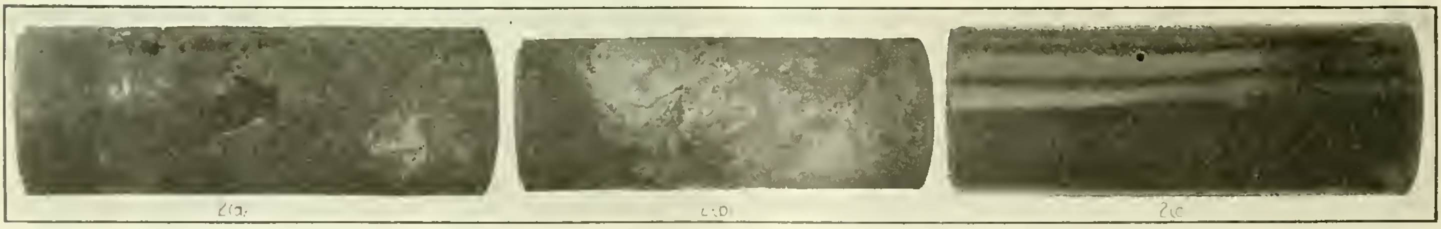


Fig. 2—(a) Corroded Pipe. (b) Holes Welded and New Material Added by Oxy-Acetylene Process. (c) The Same Pipe After Machining.

Much work of this character can be done while the pipe still is in place and requires no very great amount of experience. Steam pipe and similar large steel or iron pipe can be repaired in the same way. The cost of course depends upon the amount of work involved.

The same equipment which is used to do this work can be used to make repairs of all broken machinery parts. Gear teeth can be welded in, crank shafts can be repaired, connecting rods and cam shafts can be made as good as new. Any standard oxy-acetylene welding equipment can be used to do this work, the only requirement being that a good mixture of the gases be secured.

The illustrations for this article were furnished by the Searchlight Company, Chicago.

REVIEW OF RECORDS OF CONCRETE CASING AND LINING STEEL AND WOOD STAVE PIPE SIPHONS.

IV.

Inverted siphons are a feature of nearly every aqueduct of great length. Such structures are of four kinds mostly: (1) Lined tunnel in rock, (2) reinforced concrete tube, (3) steel pipe, and (4) wood stave pipe. Of these four kinds steel pipe and wood stave pipe have been most numerously employed. Though both suffer in comparison of desirability they have some very notable advantages. Recent years, therefore, have witnessed numerous efforts to strengthen the steel pipe and the wood stave pipe siphon in its one weak feature and a review of the records of one of these efforts, namely, casing and lining steel pipe with concrete, is the purpose of this discussion.

Cement lined pipe was developed and much employed many years ago for New England city water works distribution systems. They are now little else than a relic of past practice even in their native communities. The concrete cased and lined aqueduct siphon of steel is on the contrary a comparatively recent development and its employment is likely to continue. Its construction is wholly distinctive; the casing and lining are constructed in the field succeeding the completion of the steel pipe and are essentially special tasks of concreting. It is from this point of view alone that they are considered here.

The number of steel cased and lined steel pipe siphons is considerable, but all are connected with a few works and the greater number with one work, the Catskill Aqueduct. While this condition deprives experience of variety it has concentrated study of methods and materials with perhaps a greater net result in knowledge gained. The list of samples considered comprises fourteen siphons on the Catskill Aqueduct and one siphon on the Western Aqueduct for the Metropolitan Water District of Massachusetts. The Western siphon is short, being the approach at one end to the Wabun Hill pressure tunnel. The Catskill Aqueduct siphons vary in length from upward of 600 ft. to upward of 6,000 ft.

Catskill Siphons.

The fourteen concrete embedded steel pipe siphons for the Catskill Aqueduct have the following dimensions:

Name.	Length, ft.	Max. head, ft.	Diameter, ft.
Esopus	2,110	107	9½
Tongore	696	72	9½
Washington	3,281	90	8½
Foundry Brk.	3,778	192	9½
Indian Brk.	608	70	9½
Sprout Brk.	2,224	234	9½
Peekskill	6,671	340	9½
Hunter's Brk.	1,493	110	9¾
Turkey Mt.	1,510	92	9¾
Harlem R. R.	694	60	9¾
Kensico	1,625	50	9¾
Elmsford	1,490	68	11¼
Fort Hill	1,267	72	11¼
Bryn Mawr	5,584	214	11¼
Total	33,031	...	....

Two contracts were let for construction, but each siphon was constructed as an isolated work.

Sections.—The general type of section adopted is shown by Fig. 1, but details were modified, depending on location and other conditions. In general the outside casing was of horseshoe section and of concrete; the inside lining was invariably a 2-in. ring of 1-2 cement-sand-grout. The pipe was lined by usual methods on concrete cradle blocks and was completely connected up and given a hydrostatic test for tightness previous to casing and lining. The concrete construction methods also are considered here.

Concreting Plants.—As stated before each siphon was isolated and so was handled as a separate problem in plant provision and layout; typical mixing and handling plants were as follows:

For the Foundry Brook siphon, 3,800 ft. long, a service railway on which cars were operated by cable was constructed along the full length of the siphon. This railway was supplemented by a 650-ft. cableway spanning the stretch of siphon in the bottom of the valley.

At Indian Brook the main plant consisted of an 800-ft. span cableway covering all the siphon; a 70-ft. boom derrick at the stream crossing proper, a crusher and mixer, and the necessary boilers.

At Peekskill siphon concrete was handled from a mixing plant at one end to part of the work by cableway and derricks and other parts were served by portable mixers and by hand mixing at forms.

At Elmsford siphon concrete was hauled from mixer in Koppel cars operated by hand or on steep slopes by cable and the cars were dumped directly into the forms.

At Bryn Mawr and Yonkers siphons a 3-ft. gage track extended from the mixer along the work and on this were run two-car trains carrying four buckets of concrete which were handled from cars to forms by traveling derricks or at places too steep for operating derricks side dumping cars were used and the concrete shoveled from portable platforms at the sides of the tracks into the forms. On other parts, a track was laid over the siphon and cars dumped directly into the forms.

Concreting Casing.—Concreting the outside casing of the pipes was done by ordinary full circle methods, but sometimes in two lifts, the first of which came up to about mid-height of the steel pipe. The following are typical examples:

At Indian Brook the lower forms were wood panels and the upper forms were steel, consisting of ribs 5 ft. apart and steel connecting plate. Lengths of 10 to 30 ft. were concreted, the forms being shifted several panels at a time by cableway.

At Peekskill the covering was applied in full circles, using steel forms and wood forms with steel ribs.

At Elmsford the forms consisted of arched angle ribs and board lagging with steel plate bulkheads or end forms. A 30-ft. length was concreted in one operation.

Lining with Forms.—The placing inside of the steel pipe of a lining only 2 in. thick was the unusual feature of the Catskill steel siphon concreting. Unfilled, the pipe flattened out and even when filled the vertical diameter was short at places of minimum hydrostatic pressure. No kind of traveling form could therefore be used; one was tried and proved useless. The form finally adopted and the method of grouting the lining are shown by Figs. 2 and 3. Described, the procedure was: An invert 8 ft. wide of 1-2 mortar was placed and screeded to shape as shown by Fig. 2. Overlapping the invert was placed a wood form built of curved panels 8 or 16 ft. long and about 2 ft. wide. These panels were constructed of ⅞-in. tongued and grooved boards nailed to 2-in. ribs spaced 2 ft. apart. The ribs were cut so as to form where the panels were fitted together a knuckle and groove joint. A series of these panels would be wedged together to cover completely the inside of the pipe with the exception of about 6 ft. of invert. Longitudinal timbers were placed at the joints in the panel ribs and braced apart by diameter pieces. The space the lagging from the shell spacers as shown in Fig. 2 were used. This form proved adjustable to variations in diameter and except as noted later was used for all steel siphon lining. The lining was placed working up-grade in 15-ft. lengths as shown by Fig. 3. The grout was mixed in a duplex box so arranged that one batch was being mixed while the preceding batch was being discharged. The mixture was made about the consistency of cream. During pouring the form was constantly tapped to release the air. About 16 one-bag batches of 1-1 mixture and 24 one-bag batches of 1-2 mixture were required for grouting a 15-ft. section, the richer mixture being used below the springing line. With three sets of forms a 15-ft. length was concreted each day or 90 ft. per week.

Lining with Cement Gun.—At the Hunters Brook siphon a variation from the usual method of lining was tried; the lining, except a hand-placed invert section, was placed by cement guns.

The charge of dry materials on the Hunters Brook lining was two buckets (coal hods) of 1,080 cu. in. per charge. The volume for 1 lin. ft. of the 2-in. lining equals 5.2 cu. ft. and for the 2 7/16-in. lining, 6.12 cu. ft. The bottom, or invert, excluding the first 175 ft., was placed by hand. As the "gunite" was shot on with great force, a small quantity of sand bounced off until the steel sheet received a coating of cement. The small amount bounding off after this had no cement adhering to it. To allow for this excess the proportion of sand was increased one-half portion, or about 14, so the proportions of the dry mixture were 1 cement to 2½ sand, which gave 1 part cement to 2 parts sand for the lining, as required. The siphon had been under hydraulic test while the concrete envelope was being placed; it then was drained, the bulkheads removed and left idle through three cold months. This caused considerable fine rust on the inside of the pipe, which had to be removed before placing the lining. This was done by first scraping with heavy short-handled scrapers, then brushing thoroughly with wire brushes, finally wiping down with old sacks. Better results were obtained with brushes having short wires, as they cut the rust better than the long wires, which are more flexible. When a stretch of about 75 ft. had been efficiently cleaned, the gun was brought into play, to wash down the pipe with a stream of water combined with compressed air. The next operation was to put a "spray coat" of a very wet "gunite" on the cleaned pipe. This coat was only about 1/16 in. thick and was simply for the purpose of keeping the pipe from rusting until the lining was placed. The pipe being of alternate inside and outside courses, to facilitate the screeding, it was decided to complete the lining of alternate courses in a stretch before shooting on the intermediate courses. For this reason the "spray coat" was scraped off while it was wet, in an 8-in. band from the extreme ends of the intermediates.

The screed for the alternate was pine board 4 in. high, 1 in. thick and 8 ft. long. On the ends were wooden blocks of the proper height to give the required thickness of lining, and along the face of the screed was a strip of thin sheet steel. For the intermediate the blocks were left off and the ends of the screed rested on the hard finished face of the alternates. The screed was the only form of any kind that was used even at the manhole and blow-off connections. After the "spray coat" came the first coat, which was from ½ in. to ¾ in. thick, placed successively on three or four alternates. By following this procedure, the "gunite" had partially set upon the first alternate by the time the first coat had been shot on the third or fourth. Then another coat was put on alternate number one, making the thickness about 1¾ in. The same operation was followed on the remainder of the alternates. The screed was run over the courses to see that the thickness was about even. Following this came the final coat in the same order as before. As soon as this was shot, the screed was used to ascertain that the proper thickness was on and that there were no depressions. In case there were holes the gun filled them and then the surface was screeded, making all ready for the floating and flat troweling of the finished surface. The other three or four were filled in before the gun was used on the remainder of alternates of the stretch. The screeding was done by moving the screed back and forth with the length of the pipe, at the same time working it around the circumference. The intermediates were worked in like manner until the stretch was finished, then another stretch started. If a part of the lining fell off before it set, the gun built the cavity up and bonded it in very efficiently, with the rest of the lining. The invert, placed by hand to a chord width of 7 ft., had to be finished with clean, sharp edges on the ends and sides. The hand-worked invert was placed before the rest of the lining of the siphon, all except about 75 ft. Because of the invert being placed first, care had to be used to guard against sand pockets. These pockets were liable to form by the particles of sand dropping off when the lining was shot, lodging on the sides of the invert against the pipe, then shot over before being removed by hand. The final coat of the "gunite" required but very little floating and troweling to give a good surface. The finished surface was very smooth and free from all marks. After setting up and drying out, some hair cracks were found which were probably due to shrinkage or maybe expansion or contraction, as the pipe was protected by only the concrete envelope and by backfilling about up to the level of the horizontal diameter. The lining was placed during the hottest part of the summer. The ventilation was obtained through the open ends of the pipe, a 2-ft. manhole about half way between the ends and by 2-in. plug holes in the top every 15 ft. When the air became too foul or filled with dust a current of compressed air was turned on until it cleared. The light was furnished by four large track gasoline vapor lamps. Later on electricity was tried.

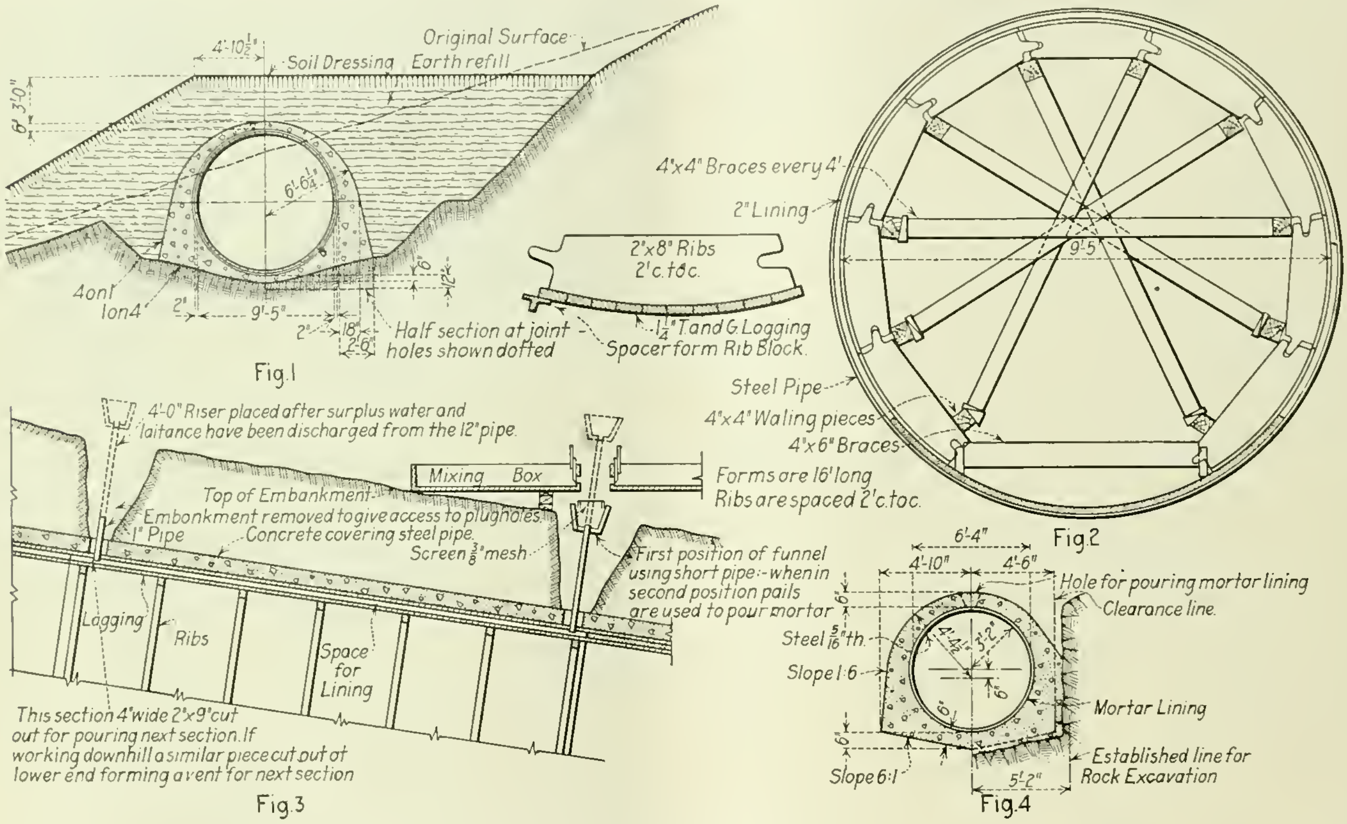

Original Surface
4'-10½"
Soil Dressing
Earth refill
6' 3'-0"
6'-6¼"
4 on 1
1 on 4
2'
9'-5"
2"
18"
2'-6"
6"
12"
Half section at joint holes shown dotted
2"x8" Ribs 2' c. to c.
1¼" T and G Logging
Spacer form Rib Block.
Fig. 1
4"x4" Braces every 4'
2" Lining
9'-5"
Steel Pipe
4"x4" Waling pieces
4"x6" Braces
Forms are 16' long Ribs are spaced 2' c. to c.
Fig. 2
4'-0" Riser placed after surplus water and laitance have been discharged from the 12" pipe.
Mixing Box
Top of Embankment
Embankment removed to give access to plugholes.
1" Pipe
Concrete covering steel pipe.
Screen ⅜" mesh
First position of funnel using short pipe:- when in second position pails are used to pour mortar
Logging
Ribs
Space for Lining
This section 4" wide 2"x9" cut out for pouring next section. If working downhill a similar piece cut out at lower end forming a vent for next section
Fig. 3
6'-4"
4'-10"
4'-6"
Hole for pouring mortar lining
Clearance line.
6"
Steel 5/16" th.
4'-4½"
3'-2"
Slope 1:6
6"
6"
Mortar Lining
6"
Slope 6:1
5'-2"
Established line for Rock Excavation
Fig. 4

Fig. 1—Section of Concrete Covered and Lined Steel Siphon, Catskill Aqueduct. Fig. 2—Form for Lining Catskill Aqueduct Steel Pipe Siphon. Fig. 3—Method of Pouring Lining, Catskill Aqueduct Siphon. Fig 4—Section of Concrete Covered and Lined Steel Pipe Siphon, Weston Aqueduct.

The compressors used were as follows: One high-pressure compressor, mounted on a horse-drawn truck, with gasoline engine. The compressor furnished 105 cu. ft. of free air per minute. Combined with this was a storage tank and an automatic unloader. This unit used about 25 gal. of gasoline per day of eight hours. Connected with unit No. 1 were two other engines and compressors of the same make, but with a compressor giving 110 cu. ft. free air per minute, having an automatic unloader. Each of these used about 20 gal. of gasoline per 8-hr. day. The water for cooling the jackets and for the "gunite" was pumped directly from the brook with a vertical gasoline engine and pump combined, using about 6 gal. of gasoline per 8-hr. day. The cleaning of rust from the pipe was done by a foreman and five laborers, which was part of the main contract, while the lining was a sub-contract. For the operation of the gun and all work connected with the lining the force account consisted of superintendent, timekeeper, operator of gun, four plasterers, two mechanics, eight laborers, two nozzlemen and a team and driver. All this force worked 8 hours per day for 6 days a week. The smallest number of charges in any one day was 132, or about 83 cu. ft. of dry mixture; the largest number was 600, or about 375 cu. ft. To get the volume sticking to the surface it is necessary to deduct 14 per cent, after which the volumes were: Minimum 71 cu. ft., maximum 322 cu. ft. and average 107 cu. ft.

Exceptional space has been given to the description of gunite lining, for, with present improved guns and the perfecting of methods, it has great promise as a means of lining steel pipe.

Weston Siphon.

The cross-section of the lined and covered pipe and its location are indicated by Fig. 4. The example is of particular interest for the complete records of costs and because of the use of steel forms for placing the lining.

Concrete Casing.—About 451 cu. yd. of concrete was used for anchorages and backing for 60-in. pipe (see Fig. 4), and for covering the 80-in. pipe, and nearly all was used for the latter purpose, so that the cost figures are quite true. The quantity of concrete required for covering 80-in. pipe averaged about 0.84 cu. yd. per linear foot of pipe line. This concrete was mixed in the proportion of 380 lbs. of Portland cement to 10 cu. ft. of loosely compacted sand and 18 cu. ft. of loosely compacted mixture of 2-in. and ¾-in. size crushed stone, making a 1:2.78:5 mixture. At the west portal the concrete was hand mixed and as the trench was almost entirely in earth, wooden forms were used for the entire section. At the east portal, where the trench was almost entirely in rock, the concrete was placed up to the springing line of the arch, without forms, wooden forms being used for the remainder of the section. At this place the concrete was mixed in a steam-driven Smith mixer and hauled about 100 ft. Before constructing the forms and placing concrete around the steel pipe, it was braced inside to true circular form, and the outside was cleaned to bright iron with a sand blast and then painted with a thick coat of cement paint made by mixing 10 lbs. of cement with 5 lbs. of water. Holes were left in the concrete at the top of the pipe, through which the cement mortar lining was placed later. The cost of the work has been sub-divided to show the cost of forms separate from the cost of mixing and placing the concrete, as follows:

Item.	Cost per cu. yd.
Forms—	
Superintendence and general labor	$0.12
Labor	0.65
Teaming	0.05
Lumber	0.20
Small tools, etc.	0.07
Incidental expenses and insurance	0.04
Plant, interest and depreciation	0.001
Total cost	$1.131
Mixing and Placing Concrete—	
Superintendence and general labor	$0.27
Labor	1.50
Teaming	0.13
Sand	0.53
Cement	1.63
Sand blasting (4.6 ct. per sq. ft. cleaned)	0.78
Small tools, etc.	0.20
Incidental expenses and insurance	0.12
Plant—	
Transportation, erection, repairs, operation and dismantling	$0.60
Interest and depreciation	0.07
Total cost	$5.83
Grand total	$6.961

Mortar Lining of 80-in. Steel Pipe (363 lin. ft.).—The mortar lining for the 80-in. steel pipe was made 2 in. thick and was cast in place by pouring a thin mortar into the space between the steel pipe and a central collapsible steel form of the Blaw type, which was held in correct position by means of adjustable bolts, located around the circumference of the form and which were brought to a bearing upon the steel pipe so as to provide the desired 2-in. space for the mortar. The forms were made in sections 7 ft. long, each section consisting of five circular segments bolted together with an adjustable wooden keypiece at the top. The mortar was poured through 2-in. holes in the top of the pipe, the lining being cast in sections 14 ft. long, without interruption in the flow of mortar after the pouring of a section was once started. The end of the section was closed by means of a hose extending around the circumference and expanded by means of water pressure, forming a bulkhead at the end of the annular space between the steel pipe and the form. Before setting up the forms, the interior of the pipe was cleaned to bright iron with a sand blast and it was then painted with a cement wash in the same manner as the outside of the pipe, described under Item 9. The mortar was mixed in the proportion of 1 part of Portland cement, 2 parts of sand and water amounting to about 25 per cent of the volume of these materials.

On account of the short length of pipe to be lined, the mortar was mixed by hand in barrels supported on a wooden platform above the top of the pipe. One cubic yard of mortar required four barrels of cement, and was sufficient for lining 7.9 ft. of the pipe.

The cost of the work has been subdivided to show the cost of forms separate from the cost of mixing and pouring the lining, as follows:

Item.	Cost per cu. yd.
Forms—	
Superintendence and general labor	$0.13
Labor	0.74
Teaming	0.04
Small tools, etc.	0.08
Incidental expenses and insurance	0.05
Rental, transportation and repairs of forms	0.77
Plant, interest and depreciation	0.002
Total cost	$1.812
Mixing and Pouring Lining—	
Superintendence and general labor	$0.12
Labor	0.67
Sand blasting	0.97
Sand	0.21
Cement	0.74
Small tools, etc.	0.07
Incidental expenses and insurance	0.05
Plant, interest and depreciation	0.002
Total cost	$2.832

Summary:	Cost per cu. yd.	Cost per lin. ft.
Superintendence and general labor	$ 1.97	$0.25
Labor	11.10	1.41
Teaming	0.29	0.04
Sand blasting	7.62	0.97
Sand	1.66	0.21
Cement	5.80	0.74
Small tools, etc.	1.24	0.15
Incidental expenses and insurance	0.79	0.10
Rental, transportation and repair of forms	6.03	0.77
Plant, interest and depreciation	0.03	0.004
Total cost	$36.53	$4.644
Value of work	45.50	5.78
Profit	$ 8.97	$1.136

Discussion.

The distinctive concreting feature of the kind of work being considered is the placing of the thin inner ring or lining. There are three requisites in performing this task: (1) The ring must be uniformly thick, smooth and in one piece, preferably; (2) the lining and steel shell must be in the most close adhesion contact possible; (3) the lining must maintain its integrity; that is, not crack or scale or lose contact with the shell.

Steel pipes of the diameters used for aqueduct siphons do not have a constant-radius perimeter. The shell is not a true circle. When laid on side the shell flattens down. Filling the pipe removes this distortion to a degree depending upon the internal pressure or upon the head of water. Many ratios of horizontal to vertical diameter may then appear in a steel pipe siphon when the head varies from little or nothing to several hundred feet. Also steel pipe siphon has vertical curvature. To secure uniform thickness of lining ring a means of forming this ring is necessary which permits of being adjusted to variations of alinement and circumferential shape.

Plastering by means of the cement gun or by more ordinary methods is perfectly adjustable to varied shape of shell. Plastering by ordinary methods does not guarantee durability. Adhesion is uncertain where cement mortar is applied to a metal surface or even when one cement plaster coat is added to another. Several coats are required to build up a 2-in. lining and each introduces a separate danger from separation and scaling. By expensive and troublesome precautions much of this danger may be eliminated, but then the cost becomes excessive. These statements are not based on records of actual use of plastered lining, but their truth is attested by experiments considered by the Catskill Aqueduct engineers.

Cement gun plastering as practiced at Hunters Brook siphon on the Catskill Aqueduct eliminated danger of striation and appeared to ensure reasonably good adhesion to the steel shell. It exhibited certain minor faults. The shooting developed a heavy dust which had to be evacuated by ventilation. The mortar deposited was so dry that wetting of the lining was essential to permit perfect curing. The waste sand and cement from rebounding mortar had to be watched with care and cleaned away from places where it might become embedded in the lining. It required repeated sounding to keep the lining to exact thickness and finally troweling was necessary to obtain a smooth surface. With the dangers indicated guarded against the gunite lining was highly satisfactory and its use was discontinued solely because of its greater cost under these conditions.

So far as practice has developed the weight of evidence is in favor of lining steel pipe, using concentric interior forms. On the Weston Aqueduct siphon a rigid full circle steel form was used successfully; the pipe was of comparatively small diameter and the flattening was probably negligible. The abutment also was straight. On the Catskill siphons, which were much larger, the flattening was sufficient to prevent use of full circle forms or forms whose perimeter curve could not be modified to correspond with vagaries of the shell diameter. A part-circle form with flexible arc was employed. This required the invert lining to be placed separately. As at the Weston siphon the form was grout filled.

Perfect adhesive contact of lining with steel shell is somewhat uncertain. Examination of lining on the Catskill siphons showed "hollow" spots when the lining was sounded with a hammer. At some of these spots the lining was cut through, however, and the space between lining and shell was found to be "almost infinitesimal" in width. Test sheets of metal covered with mortar exhibited similar "hollow" spots, but after long immersion during which the water penetrated the concrete to the steel the shell at these places showed no rust. To secure the best possible adhesion the lining should be placed against a thoroughly clean and unrusted surface. At the Weston siphon a sand blast was used to clean the pipe before concreting. At the Catskill siphons the pipe was given an acid bath and whitewashed at the mill. This did not wholly prevent rust, but the rust was merely a yellow film and was considered uninjurious.

The records indicate that success in preserving the integrity of thin lining of steel pipe depends upon perfect curing of the concrete or mortar. No checking of lining was observed except where very dry gunite mortar was used and this was corrected by keeping the mortar wetted during curing. The grouted lining had of course ample water contact for perfect curing..

Costs of lining the Weston siphon are given in detail above. Records of the cost of lining the Catskill siphons are not available. The contract prices were: For 9½-ft. pipe, $2.50 per lineal foot; for 9¾-ft. pipe, $3 per lineal foot, and for 11¼-ft. pipe, $3.50 per lineal foot. These figures give cubic yard costs ranging from $14 to $16 per cubic yard.

RESULTS OF FIRST YEAR'S EXPERIMENTS WITH SMALL SEWAGE TREATMENT PLANTS BY U. S. PUBLIC HEALTH SERVICE.*

By Leslie C. Frank, Sanitary Engineer, U. S. Public Health Service, Washington, D. C.

In attacking the problem of small-scale sewage treatment it is desirable to emphasize strongly the fact that the experiments by the very nature of the problem, should be prolonged. Most sewage treatment devices show seasonal variations and the result of one season's experimental work has about the same significance as a single laboratory experiment. It is by no means true, for example, that a sand filter which gives certain results under given conditions of operation one year may be expected to give the same results under the same conditions the next year. Accumulation phenomena, such as the gradual clogging of the pores of the sand, may occur and cause entirely different results the second or later years of operation. The following discussion of some of the first year's Public Health Service experiments is therefore very tentative, and no hesitation will be felt in subsequent progress reports in modifying any statement here made.

The devices that are being or will be subjected to experiment during these investigations are: Imhoff tank, biolytic tank, sand bed, contact bed, sprinkling filter, and automatic disinfection apparatus. Generally, more than one of the above devices will be used in combination. The combinations which seem most promising are being studied first. Only one combination is discussed here, that of the Imhoff tank and sand bed, as it is not considered that the other investigations have proceeded sufficiently far to merit any discussion.

Sources of Sewage Tested.—Sewage was tested from two sources. The sewage subjected to the most careful test was that coming from about 25 people comprising a nurses' dormitory and one residence. The sewage flow was about 100 gal. per capita daily. The occasional samples of raw sewage gave an average value somewhat over 1,000 parts per million total solids and 177 p. p. m., for 24 hour 20° C., oxygen demand. The other sewage used for testing was that from about 60 people in a small community in Chevy Chase, Md. The latter plant is being used merely as supplementary to the more important Hygienic Laboratory Testing Station.

Design of Experimental Imhoff Tank.—It was not considered certain that an Imhoff tank would be adaptable to small plants, for the small plant sewage would generally be stronger, contain more grease, and its flow be more irregular. It was feared that the presence of large quantities of grease might result in scum difficulties in the first compartment of the settling chamber, and that the very low night flow might result in the sewage becoming septic. In addition the depth of the small tank would for economic reasons probably have to be limited to about 10 or 12 ft., whereas large tanks are generally 20 ft. or more in depth, and the depth of the tank is considered by many authorities to have an important effect on the quality of the digested sludge.

In designing the experimental Imhoff tank the following points were considered: volume and proportions of settling chamber, inclination of partition walls, scum boards, clearance and overlap of slot, treatment of grease, volume of sludge chamber.

Volume of Settling Chamber.—The volume of the settling chamber determines the detention period. If the detention period be made too short, the settleable solids will be incompletely removed, and if too long, the sewage will become septic. In the United States the settling chamber for large Imhoff tanks is usually made equivalent to 1/9 the daily flow, which is equivalent to a mean detention period of 2.6 hours. It was not considered advisable to design the settling chamber for a small tank on this basis on account of the wider variations of flow. It was estimated that the variations in flow might be properly allowed for by assuming the daily flow to take place in 12 hours and by giving a detention period on this basis of three hours, in other words, by making the settling chamber equal in volume to ¼ the daily flow, which is equivalent to a mean detention period of 6 hours instead of 2.6 hours as in the large plants. It was decided to risk the possible danger of making the effluent septic.

Relative Proportions of Settling Chamber.—The volume of the settling chamber is not alone responsible for the degree of removal of settleable solids. The chamber must neither be made so short and wide as to result in short-circuiting through local currents, nor so long and narrow as to approach the proportions of a channel, in which case swirling velocities will occur and hinder sedimentation. The proportions selected must depend largely upon experience, and while considerable experience is available for large plants, this is not so true of small plants. However, the dimensions of the experimental tanks were arbitrarily placed within the range of large-scale experience. The proportions of length, width, and depth were for the Hygienic Laboratory tank 8:3:5, and for the Chevy Chase tank 11:1.7:3.

Inclination of Partition Walls.—The inclination of the partition walls separating the settling chamber from the sludge chamber was made 2.6 vertical to 1 horizontal in the Hygienic Laboratory tank and 1.5:1 in the Chevy Chase tank. In small plants steepness of partition walls is even more important than in large plants, because in the latter the attendant may generally be relied upon to squeegee the inner surfaces if the accumulated sludge refuses to slide properly towards the slot, whereas in the former no such attendance can be expected. It was for this reason that it was decided to try different inclinations.

Slot Clearance and Overlap.—In large tanks the clearance of the communicating slot is generally made from 6 to 8 in., while the overlap is generally made about 8 in. This becomes a very serious matter for small plants. With a partition inclination of 1.5:1 an 8-in. slot clearance and an 8-in. overlap mean roughly about 2 ft. 3 in. vertical distance between the lower edges of the two partitions, which is a considerable proportion of a total depth of 10 or 12 ft., and deducts that much from the sludge capacity. It was decided to reduce the slot clearance arbitrarily to 5 in. and the slot overlap to 6 in. There is some question whether a small tank really needs so large a slot clearance, as it seems likely that the slot cloggings which occur in Imhoff Tanks are often caused by the fact that the passage of settled sludge through the slot is not continuous, but intermittent. The sludge particles may be conceived as accumulating upon the inclined surfaces until the sliding thickness is reached, when the mass will begin to slide and pass rather suddenly towards the slot, perhaps developing one or more folds in the region of the slot. The clearance of the slot must be sufficient to pass these sliding sheets. The thickness of these sliding sheets and the extent to which they will fold upon themselves will depend upon the inclination and length of the surfaces upon which they develop. Since the length of these inclined surfaces will naturally be less as the size of the tank diminishes, it seems logical to reduce the slot clearance accordingly.

---

*From a paper before the New Jersey Sanitary Association.

Grease Chamber.—On account of the tendency of grease in fresh sewage to mix with fecal and other solid matters, and to cause the whole mass to float and become sufficiently dry to prevent decomposition, it was decided to place a horizontal screen at the water level in the first compartment of the settling chamber. This would keep the floating solids submerged, and allow them to become waterlogged and sink to the bottom. The mixing caused by the incoming sewage would also tend to separate the grease from the other solids. The introduction of this horizontal screen has apparently been successful. There have never been more than 2 in. of grease under the screen in the Chevy Chase tank and at the Hygienic Laboratory the material which has collected, while more voluminous, has been found to be almost pure grease, the removal of which was not at all objectionable.

Gas Vents.—Gas vents were provided on either side of the settling chambers. At the Hygienic Laboratory their total area is 8 sq. ft. and at Chevy Chase 40 sq. ft.

Sludge Capacity and Depth of Tanks.—Sludge capacity was provided for about 2 cu. ft. per person at the Hygienic Laboratory tank and 4 cu. ft. at the Chevy Chase tank. After providing the necessary settling chamber and sludge room capacities the total depth of the Imhoff tank at the Hygienic Laboratory was 10 ft., and at Chevy Chase 12 ft.

Sludge Removal and Disposal.—No permanent sludge pipe was included in the experimental tanks. Instead it was decided that when sludge was to be removed an ordinary bilge or trench pump would be used. No special provision was made for the disposal of the sludge, for the possibility was anticipated that for most small plants shallow trench disposal could be used. A relatively small area would be required.

Scum Boards.—One scum board was provided at the influent end and one at the effluent end of the settling chamber. The penetration below minimum water level of the first scum board was made 3 ft. because it was to serve also as one wall of the grease chamber. The penetration of the effluent scum board was made 2 ft., which was later found to be excessive.

Covers.—The tanks were provided with covers as a safety feature, as a possible preventive of odors, and to keep the grease and scum from drying.

Sand Bed and Dosing Chamber: Function.—The function of the sand bed is to satisfy as much as possible of the oxygen demand of the non-settleable organic substances in the sewage, and thereby to deliver an effluent which will not cause nuisance and which will remove part of the burden of possible water purification plants. The function of the dosing chamber is to control the manner of the application of the settled sewage upon the sand bed in such a way as best to promote the activity of the oxidizing organisms.

General Description.—The experimental sand bed as designed for the Hygienic Laboratory plant consisted of a layer of sand 2 ft. deep and 7x12 ft. in area, resting upon a drainage layer of gravel 6 in. deep. The effective size of the sand was 0.24 mm. The dosing chamber was 3 ft. in diameter and contained a 3-in. Miller sewage siphon of 15-in. draw. Each dose from the dosing chamber discharged a layer of sewage upon the sand bed about 0.1 ft. in depth.

Experimental Results.

Imhoff Tank. Removal of Settleable Solids.—The average total solids in the raw sewage applied to the Hygienic Laboratory Imhoff tank for three months was 1,000 p.p.m. For the same period the average total solids in the tank effluent were 330 p.p.m. The total solids settled out by the tank were therefore 670 p.p.m. The average settleable solids in the tank effluent were 14 p.p.m. Hence the total settleable solids in the raw sewage were 684 p.p.m. and 98 per cent of the settleable solids were therefore removed by the tank.

Volume of Sludge per Person.—The experimental tanks have not been operated for a sufficient length of time to justify definite conclusions as to the volume of sludge received. Our records to date indicate a probable rate of 2.6 cu. ft. per person per year at one plant and 4 cu. ft. at the other. This indicates a possible range of variation which may be expected in small tanks, apparently similar.

Condition of the Sludge.—The digested sludge is black in color, has the characteristic Imhoff sludge odor, streaks very quickly in a procelain dish, showing that it has lost its stickiness and waterholding power, but has a relatively high moisture content, generally about 95 per cent. It is probable that the high moisture content is due to the shallowness of the sludge layer. Sufficient sludge has not accumulated as yet to justify drying experiments. Its appearance, however, indicates that there will probably be no difficulty in doing this without nuisance.

Freshness of Effluent.—The mean detention period in the Hygienic Laboratory tank is about five hours instead of six hours, as the flow has been somewhat higher than was expected. At Chevy Chase it is about six hours. These are higher values than those employed in large tanks, but the effluent has practically never been septic and has had at all times the odor of fresh sewage. It seems likely, therefore, that where sewage is settled so close to the source as is usually the case with small tanks, a mean detention of five or six hours will not render it septic or foul-smelling.

Scum and Foaming.—Both heavy scum formation and foaming occurred in the operation of the tanks. The most significant run on the Hygienic Laboratory tank began on Nov. 19, 1914. Scum commenced to form almost immediately in the side vents and apparently continued increasing in thickness until July 5, 1915, with relatively little sludge being deposited in the sludge chamber. The scum was yellowish-gray, except the top quarter inch, which was black. Unless the scum was stirred no odor could be perceived outside the tank, even if the covers were removed. Upon spading or stirring, however, a distinct fecal odor could be noticed. At this time a sudden change took place and nearly all of the yellowish-gray scum changed to gray foam and began to boil over the top of the tank. Spading the scum caused it to deflate and collapse, but it soon became necessary to spade the scum twice a day in order to prevent it from foaming over. Finally, on July 13 and 14, some of the foam was removed and buried, in amount about 21 cu. ft., or somewhat less than 1 cu. ft. per person. It was impossible to determine what proportion this was of the total scum and foam present. From then until now, four months later, no further foaming has been observed. The scum is now entirely different, consisting mostly of seeds, grease, bits of cloth, and other not easily decomposable substances. It cannot be said, therefore, that difficulties with scum and foaming have occurred to a serious degree, since the foaming-over period at the Hygienic Laboratory lasted only about 10 days, and this could probably have been prevented by an earlier removal of the scum or by the provision of larger gas vents.

Sand Bed.—As above stated, the sand bed design intended a sand depth of 2 ft., but on account of compacting the depth decreased to 18 in. after a few doses had been applied. The results, however, were so good that it was decided not to increase the depth, but to determine the purifying power of 18 in. The rate of dosing was about 200,000 gal. per acre per day. For the month of October, 1914, the average dissolved oxygen present in the effluent was 5.4 p.p.m., the average 24 hour 20° C. oxygen demand was 2.2 p.p.m. and the relative stability over 90 per cent, corresponding to a time of decolorization of methylene blue of over 10 days. During the following winter much difficulty was experienced with the sand bed and frequent rakings and spadings were necessary. The bed was provided with tongue-and-groove covers, and while these prevented the formation of ice the frequent clogging did not diminish. More attention had to be given than can be reasonably relied upon for small plants. For some reason the depth of sand decreased during the winter and spring to about 15 in. It seems probable that the frequent deep spadings caused some of the sand to pass down into the gravel layer. From November, 1914, to May, 1915, the average dissolved oxygen was 5.7 p.p.m., and the average oxygen demand 14.4 p.p.m. This included a period from April 7 to 30 when the dissolved oxygen was 2.6 p.p.m. and the average oxygen demand was 33.8 p.p.m. On May 15 green growths appeared quite copiously on the sand surface and continued forming until June 19. Several rakings were necessary during this time. From June 19 until Oct. 4 no further rakings were necessary, and during this time weeds grew in abundance on the bed, but did not visibly increase the time of passage of a dose, which was generally about 15 to 20 minutes. Occasionally there seemed to be some evidence that short-circuiting was taking place through the 15-in. sand layer, but we were not able to establish direct evidence of this at any time. During the three months of July, August and September of the past summer, the net rate of dosage was 190,000 gal. per acre per day, the influent had no dissolved oxygen, 63 p.p.m. oxygen demand, and no nitrates, while the effluent contained 2.2 p.p.m. dissolved oxygen, 12 p.p.m. of oxygen demand and 8 p.p.m. of nitrates.

Conclusions.

Our experience thus far justifies the following tentative conclusions:

(1) It is possible by means of a five-hour mean detention period in a properly designed Imhoff tank to remove from the raw sewage of small communities 98 per cent of the settleable solids without producing a nuisance.

(2) A mean detention period of six hours, based on the average daily flow, will not cause the sewage to become septic or foul-smelling if it is fresh when it enters the tank.

(3) The accumulation of a disagreeable mass of grease and fecal matters in the first compartment of the settling chamber may be prevented by the introduction of a horizontal coarse mesh screen at the water level of this chamber. The screen keeps the floating matters submerged and apparently results in all fecal matter sooner or later becoming waterlooged and sinking through the slot into the sludge chamber.

(4) It is too soon to state with conviction the amount of digested sludge that may be expected from small-scale tanks, but one tank indicates an apparent accumulation of 2.6 cu. ft. per year per person and another tank 4 cu. ft.

(5) The only period during which the Imhoff tanks required daily attention was the foaming period, which lasted about 10 days, and during which time some of the foam had to be removed and buried. At all other times attention once a month at the most was ample.

(6) Since the foaming period has been passed the scum formation has been slight.

(7) The decomposed sludge obtained from the small-scale Imhoff tanks resembled that obtained in large tanks except that it had a much higher moisture content. This may perhaps be explained by the shallowness of the sludge layer.

(8) A 15-in. sand bed dosed with settled sewage at a net rate of 190,000 gal. per acre per day during the second summer reduced an average oxygen demand of 63 p.p.m. to 12 p.p.m. (24-hr. 20° C.). This is probably ample purification for many cases, but insufficient for others.

(9) The sand bed required very little attention during the summer months, but what would seem to be a prohibitive amount of attention during the winter months, even though covered with a tongue-and-groove wooden cover.

(10) No nuisance was produced during the summer months by the dosing of the uncovered sand bed with the Imhoff tank effluent.

(11) The growth of weeds on the sand surface did not seem to have an unfavorable effect upon the operation of the sand bed.

In General.

The foregoing work has indicated the desirability of continuing the experiments upon Imhoff tanks in order to confirm the past satisfactory results, and the desirability of continuing the experiments upon sand beds in order to improve only fairly satisfactory results. Further experiments will be made upon deeper sand beds at lower rates of dosing.

The work has been done under the general direction of Prof. Earle B. Phelps. The analytical work was done by Sanitary Bacteriologist H. L. Shoub. The writer, with Sanitary Bacteriologist C. P. Rhynus as assistant, was in immediate charge.

A LONG-SPAN PLATE GIRDER SWING BRIDGE.

The new double-track bridge across the Lachine Canal, near Montreal, Canada, consists of an approach deck plate girder span of about 90 ft. and a swing span over the canal, the latter being of the deck plate girder type, 239 ft. 7 in. long, 13 ft. 6½ in. deep at the pivot pier, and 8 ft. .0½ in. deep at the ends. The two arms of the swing span are of unequal lengths, the difference in length being about 5½ ft. Each span consists of four girders, the two center girders each being spaced 2 ft. 6 in. from the center line of the bridge and the outside girders each 10 ft. 6 in. from the center line. Each girder weighs 112 tons, the total weight of the swing span being 615 tons. The swing span is operated by duplex 30-hp. motors on the center pier, controlled from the operator's house on the north bank of the canal; an extra 30-hp. motor is provided in case of emergency. The present double-track swing span replaces a single-track swing span of the through-truss type. The work was carried out without interferring with traffic.

INK VS. WATER COLOR PAINT.

A great deal of trouble was formerly experienced in posting the 50, 100, and 300-ft. scale maps, of the Water Department of the District of Columbia, by reason of the blue ink running and blotting where it had been necessary to make an erasure and reink over the place erased. Last year was begun the use of Prussian blue water color paint instead of the blue ink, and it has proved a most decidedly satisfactory remedy for the trouble. Before using the paint there was made a comparison of the fading qualities of the ink and paint by making up a sheet with two sheets of duplicate drawings, using both ink and paint, and exposing one set to the sun and weather for a period of eight days. At the end of this period it was found that the ink had faded slightly but the paint not at all. Portions of all the drawings were then erased, and the erased portions replaced, which resulted in the ink spreading and blurring, while the paint lines were as clear cut as before erasure. Less time is consumed in erasing the paint than the ink.

The Lighter Side of Engineering and Contracting

The Hoot Owl Bear.

THE *Earth Mover* is responsible for this one:

Martin Adams, who is the blacksmith for E. M. Lowrance, one day drove into Arkansas City. Meeting congenial friends, he prolonged his stay until along in the evening so that when he struck the dense woods about a mile from camp it was quite late. Having had quite a strenuous day he fell asleep and was awakened by an unearthly noise, "Hoo, hoo! hoo are yuh?" cried the voice. Martin did not wait to see, he was out of the buggy and his time to the camp was in less than nothing. Rushing up to the commissary he yelled: "Get a gun quick; a darn bear has followed me all the way down the road."

Waving the Bloody Shirt.

THE ancients were well acquainted with asphalt, Tacitus, in a description of the Mare Mortuum, written some time in the B. C.'s, gives the following account of the methods employed in collecting the material:

"At a stated season of the year the lake throws up bitumen. Experience, the mother of all useful arts, has taught men the method of gathering it. It is a liquid substance, naturally of a black hue, and by sprinkling vinegar upon it it floats on the surface in a condensed mass, which those whose business it is lay hold of with the hand, and draw to the upper parts of the vessel; thence it continues to flow in and load the vessel till you cut it off. Nor could you cut it off with brass or iron. It shrinks from the touch of blood." Presumably, when the vessel was loaded, the captain waved a bloody shirt and the surplus bitumen in terror leaped back into the lake.

A Butting Collision.

THE *Railway Age Gazette* says that a wild elephant recently charged and struck a locomotive "in the Bengal Duars." While confessing ignorance of that part of an engine's anatomy, it sounds serious enough to have given the engineman a flat wheel in the pericardium.

Sanitary Note.

THE Romans were not familiar with the virtues of tobacco. They had no plug cut, no smoking, nor no chawing. Hence they had some stringent regulations regarding spitting on the floor. History records that the amiable and lovable Emperor Caligula was particularly opposed to promiscuous expectoration. Indeed, it is recorded that the Roman pleb who expectorated upon the outer forum floor had his expectorator amputated on the installment plan. First they sheared him of his hair. Next they pulled out his teeth. Then they slit off his ears for "souvenears" in the market place. Finally they chopped off his head.

When the Trench Settled.

OLD man Ripson executed a contract for some small sewers at an army post in New York state. As he had not dug the ditch deep enough to get all the dirt back in the trenches, he made a neat mound over them with the surplus. The colonel says. "Here, you take all that surplus material away and leave the ground level. Do you want to make this place look like a graveyard?" The comeback was: "All right, colonel, I'll take it way if you insist on it, but next spring you will think some one stole the corpse."

Thrift.

JAKE PENTICOFF was a unique character. He had a large family and, although he was reasonably diligent in the use of saw and ax on the village woodpiles, he frequently came to seek aid from the town fathers. "I gotta haff a sack of flour," said Jake on one occasion. "I'm all out, and my family iss starfin'." "All right, Jake," said the official. "If you need the sack of flour and have no money to buy it with we'll get you a sack. But see here, Jake, there's a circus coming to town in a few days, and if we get you a sack of flour are you sure that you will not sell it and take your family to the circus?" "Oh, no," said Jake, "I already got tat safed up. Yes, I got money to go to circus."

In Oklahoma.

"CAN you direct me to the best hotel in town?" asked the sales engineer as a loose board in the station platform flew up and hit him. "I can," said a dry-goods salesman, who was waiting for a train going the other way, "but I hate to do it." "Why?" "Because after you see it you'll think I lied to you."

Why the Editor Left Town.

COL. PATRICK MULGREW, the official contractor of a New England city, although wielding considerable political influence, had never run for office. Last fall, however, the colonel threw his hat in the ring and announced his candidacy for county sheriff. The editor of the local paper prepared a glowing eulogy of our hero, closing his tribute with the words: "He is a battle scarred veteran." Unfortunately through a typographical error this appeared as "bottle scarred veteran." The colonel, very indignant, demanded a retraction and the newspaper man prepared a neat little explanation stating that "through an unfortunate combination of circumstances in our last issue we referred to our esteemed townsman, the Honorable Patrick Mulgrew, as a "bottle scarred veteran" when we intended to say he was a "battle scarred veteran." The next morning the editor left town. The fates were against him; another typographical error had occurred and the colonel was now a "battle scared veteran."

Too Much for a Jitney.

A SKINNER, marooned on a job in the pine sticks of southern Alabama, dropped into the commissary store at a turpentine still and said to the clerk: "Give me a nickle's worth of asafoetida." The clerk poured some into a bag and shoved it across the counter. "Charge it," drawled the intrepid muleteer. "What's your monicker?" asked the clerk. "Honeyfunkel." "It's you'rn, old timer," said the clerk. "I wouldn't write asafoetida and Honeyfunfel for 5 cents."

He Saved the Stakes.

THEY tell one on Hugh McCarten. Hugh was foreman on some railroad work in Mississippi some years ago, and the engineer going over the work asked what had become of the grade stakes. Hugh did not know, so the engineer put in some others. Again the stakes were trampled down by the teams and the engineer was quite angry in consequence. He told him that he would put them in again, but that he wanted Hugh to see that the stakes were saved the next time. A week or so later the engineer went over the road again and noticing that the stakes were gone said:

"Didn't I tell you to save the stakes?"

"Yis, and I did save thim," said Hugh; "come along wid me."

Curious, the engineer followed and in Hugh's tent, nicely piled up behind the stove, were the grade stakes.

"See," said Hugh, "I saved thim, didn't I?"—*The Earth Mover.*

Skinner Mulvey says: The boss stuck up this sign: "Those that expect to rate as gentlemen must not expectorate on the floor." Old man Dodson asked the boss where he expected him to spit—on the ceiling?

CURRENT NEWS

The Doings of the Week.

Financial, industrial and business activities were well sustained during the past week. There was no slowing up in any of the leading lines and hesitancy due to prospects of international troubles was less noticeable. Bank clearings were at the highest point reached in the last five weeks. One feature of the week from the Wall St. point of view was the strength developed in railroad stocks. This movement was accelerated by the increase in the Norfolk & Western dividend and by the strikingly favorable showing made in some of the railway reports for the month of March. There is a strong demand for high class municipal securities and public utilities issues also are popular. Railroad and industrial bonds likewise are receiving attention from investors. In the construction field the volume of new work reaching the call for bids stage showed an increase over the previous week. Numerous municipal undertakings are now being advertised, and while the majority of these jobs are small, they make up in number what they lack in size. Many lettings will be held the first week in May and some important projects will then be placed under contract. Building construction in the metropolitan district of New York City for April, based on plant filings, was heavier than in any corresponding month since 1914. The contracts awarded in April, however, show a decrease of about 18 per cent below the value reported for the same month in 1912. In the iron and steel trade new buying fell off during the past week, this, however, being ascribed mainly to the definite efforts of sellers to repress demand. *The Iron Age* states that "without regard to the demands for particular steel products, the situation is still one of a scarcity of steel as steel, and indications are that prices for some months will be determined accordingly. In general the attitude of sellers both toward domestic and foreign buyers is that of letting the urgency of demand fix the price." Rail orders included 25,000 tons for the Philadelphia & Reading Ry., 25,000 tons for the Chesapeake & Ohio Ry., 24,000 tons additional for the Southern Ry. and 20,000 tons for the Chicago & Eastern Illinois R. R. *The Iron Age* prices for finished iron and steel and for sheets, nails and wire on April 26 were as follows:

Finished Iron and Steel.	Apr. 26.	Apr. 19.
Per lb. to large buyers.		
Bess. rails, heavy, at mill	1.25	1.25
Iron bars, Philadelphia...	2.659	2.659
Iron bars, Pittsburgh....	2.50	2.50
Iron bars, Chicago........	2.35	2.35
Steel bars, Pittsburgh....	3.00	3.00
Steel bars, New York....	3.169	3.169
Tank plates, Pittsburgh..	3.75	3.75
Tank plates, New York..	3.919	3.919
Beams, etc., Pittsburgh..	2.60	2.60
Beams, etc., New York...	2.769	2.769
Skelp, grooved steel, P'gh	2.35	2.35
Skelp, sheared steel, P'gh	2.45	2.45
Steel hoops, Pittsburgh..	3.00	3.00
Sheets, Nails and Wire.		
Per lb. to large buyers.		
Sheets, black, No. 28, P'gh	2.85	2.85
Galv. sheets, No. 28, P'gh	5.00	5.00
Wire nails, Pittsburgh....	2.40	2.40
Cut nails, Pittsburgh.....	2.60	2.60
Fence wire, base, P'gh...	2.25	2.25
Barb wire, galv., P'gh....	3.25	3.25

For structural material f. o. b. Pittsburgh *The Iron Age* prices were as follows: I-beams, 3 to 5 in.; channels, 3 to 15 in.; angles, 3 to 6 in. on one or both legs, ¼ in. thick and over, zees 3 in. and over, 2.50 cts. to 2.75 cts.

Railways.—Bids have been taken by some of the larger eastern railroads on a number of excavation jobs running from 100,000 cu. yds. up to 300,000 cu. yds. No particularly large undertakings apparently have come up for letting by the eastern lines. The Northern Pacific Ry. awarded a contract to A. Guthrie & Co., St. Paul, Minn., for extension of some branch lines in Washington. The Utah Construction Co., Ogden, Utah, was awarded contract by Oregon Short Line Ry. for construction of new sidings, spurs, passing tracks, etc., on the entire main line system. The first letting for some months by a Canadian railway is now being advertised.

Roads and Streets.—A considerable amount of state highway construction is now being advertised. Pennsylvania began calling for bids last week on its first letting of the year. Rhode Island, also, is asking proposals on its first letting. Maine is advertising its second batch of contracts and Illinois is taking bids on its third letting. County road jobs also are numerous, and several good sized contracts are being advertised. One job for the Sarasota-Venice road district of Florida calls for 148,000 sq. yds. sand asphalt surface. Another job for a Tennessee County involves 60 miles of grading and 45 miles of macadam; a West Virginia County is asking bids for 19½ miles of brick or concrete road. Street paving jobs include 75,000 sq. yds. for Amarillo, Tex., and 40,000 sq. yds. for Wilson, N. C. Maine, Massachusetts, New York and Illinois awarded state road contracts. Beloit, Wis., let a 80,000 sq. yds. asphalt paving job; a West Virginia County awarded a contract for 9 miles of brick roads; low bid for asphaltic concrete pavement for Arlington Heights, Ill., was $161,868.

Bridges.—A considerable amount of small bridge construction is now being advertised by Ohio counties. One of the larger of these jobs calls for a steel superstructure consisting of one 200 ft. span and four 100 ft. spans. The County Commissioners at Bradentown, Fla., are asking proposals for 10 concrete and steel bridges to cost $40,000. The State Superintendent of Public Works at Albany, N. Y., opens bids May 23 for a bridge over the Hudson River at Northumberland and for a bridge over the Mohawk River at Schenectady.

Drainage and Irrigation.—Several good sized irrigation and drainage contracts reached the call for bids stage during the past week. Two of these jobs are for the U. S. Reclamation Service, one calling for 220,000 cu. yds. of excavation and the other for 793,000 cu. yds. The drainage work includes 500,000 cu. yds. for a district in Texas, 288,000 cu. yds. for a district in Tennessee and 200,000 to 300,000 cu. yds. in Wisconsin and 200,000 cu. yds. in Illinois.

Waterworks.—St. Louis, Mo., is again asking bids for furnishing and laying 26,900 ft. of 30 in. water pipe. Aberdeen, Wash., is calling for proposals for constructing 22 miles of 28 in. wood pipe line. Smaller jobs advertised include waterwork improvements for Alliance, Neb., and Pender, Neb., and waterworks for Milford, Tex. Cleveland, O., is asking bids for superstructure of gate and screen well house for the Division Ave. pumping station. Lima, O., voted $500,000 bond issue for filtration plant and other improvements. Low bid for Hemlock lake conduit for Rochester, N. Y., was $411,680.

Sewerage.—Sanitary District of Chicago opens bids May 18 for 8,600 ft. of 16½ ft. diameter intercepting sewer; Rochester, N. Y., extended time for receiving proposals for Sec. 1 of the intercepting sewer to May 24; Spooner, Minn., is asking for sanitary sewers and purification work. Sewer extensions and sewer systems for several small cities also are being advertised for bids.

Some Railway Contracts.

Quite a few rather unusual contracts have been let by railways this spring. Several of these undertakings comprise work that ordinarily has been done by company forces. One railway a few days ago awarded a contract for lengthening sidetracks along several hundred miles of main line. A similar job also was let by a western railroad. Last week a big trunk line road placed a contract for betterments on its entire system. This job calls for the construction of new sidings, spurs, passing tracks and various other minor undertakings. It looks as though some of the railways were beginning to realize that work heretofore handled by extra gangs could be done as cheaply and well by contract.

Municipal Bond Issues.

Bond issues for public improvements have met with an unusually favorable reception at the various elections this spring. Very few propositions to issue municipal, county or district securities for construction undertakings have failed to receive the necessary number of votes. In the middle west and in the southwest an especially large number of small municipalities have voted bonds for the building of water works and sewerage, and for street paving and other improvements. Larger cities also have taken advantage of the spring elections to provide for the financing of construction projects. The citizens of Cincinnati, O., for instance, last week authorized a $6,000,000 bond issue for a city owned rapid transit development. The favorable action of the voters on so many of the bond issues is a good indication that real prosperity has returned. The demand for municipal securities at the present time is greater than the supply. As a consequence the new batch probably will find a ready market and thus there will be more work for the contractor.

Excavation Contracts.

The dirt movers are busy these days and the idle outfits are becoming fewer. More railroad grading probably has been let in the first four months of this year than was placed under contract in the previous 12 months. Other lines of excavation also are offering opportunities for contractors to work off the rust of their equipment Some very fair sized road grading jobs have been let this spring, and a number of big earth moving operations in connection with irrigation development have been started. Drainage contractors, also, are finding work more abundant. Two jobs alone now being advertised call for the moving of perhaps 10,000,000 cu. yds. of earth. A year ago at this time the storage yard of one big manufacturer of excavating machinery was full of equipment. The other day all it contained was one lonely drag line. This in itself indicates that something is doing among the dirt movers.

Wage Increase for Labor.

May day, the customary time for labor disturbances, established a record this year as far as the building contractor is concerned. Not a strike of importance in the building trades was in force or impending. Such a condition is about unprecedented. Commonly at this time construction undertakings in half a dozen big cities are tied up by labor troubles. Anyway, labor has no kick coming over its treatment. Statistics collected by the United Press show that wage increases affecting 706,500 workers and totaling $5,368,000 monthly went into effect on May 1. Other figures compiled by government agencies show that the average wage increase—in those industries where there have been increases—in the United States last year was 11 per cent.

The Presidents of Fourteen State Societies of Engineers

Paul Hansen, President Illinois Society of Engineers.

Paul Hansen, president of the Illinois Society of Engineers, is chief engineer of the Illinois State Board of Health. He is also chairman of the Illinois Section of the American Water Works Association. He is a graduate of the Massachusetts Institute of Technology. His professional experience may be briefly summarized as follows: 1901—Summer experience with the United States Geological Survey as topographical surveyor; 1903 and 1904, with the State Board of Health of Massachusetts as assistant engineer; 1904, with the city of Columbus, Ohio, as draftsman on design for improved water supply and sewerage system; 1905, engineer for the Pittsburgh Filter Manufacturing Co.; 1906-1910, with the Ohio State Board of Health, first as assistant engineer, later as acting chief engineer and chief engineer; 1910-1911, with the Kentucky State Board of Health as State sanitary engineer; 1911 to March, 1916, with the Illinois State Water Survey as head of the division of engineering. In March of this year he won the appointment of chief engineer of the Illinois State Board of Health by the Illinois Civil Service Commission.

Paul Hansen
Illinois Society of Engineers

Clyde T. Morris
Ohio Engineering Society

Mr. Hansen joined the Illinois Society of Engineers in 1911. He has read the following papers before the society: "Stream Pollution," "Increasing the Efficiency of Small Water Works and Sewage Treatment Plants," "Public Water Supplies in Illinois," "Garbage Collection and Disposal in Small Communities."

In addition to the engagements summarized he has had a number of private commissions, including an appointment as referee engineer by the Ohio State Board of Health to decide a case arising between that board and the city of Greenville, under the so-called Bense Act, the Ohio stream pollution law.

Clyde T. Morris, President Ohio Engineering Society.

Clyde T. Morris, president of the Ohio Engineering Society, is Professor of Structural Engineering in the Ohio State University at Columbus. He was born in Morrow county, Ohio, and was educated in the public schools of the State, graduating from the Ohio State University with the degree of Civil Engineer, in 1898.

After graduation he was employed as draftsman successively by the New Columbus Bridge Co., the Youngstown Bridge Co. and the King Bridge Co. In 1902 he went to Seattle, Wash., as principal assistant engineer of the Puget Sound Bridge and Dredging Co., where he spent two years in charge of the estimating and designing department. In 1904 he returned to the King Bridge Co. as assistant engineer in the estimating and designing department, where he remained until 1906, when he accepted his present position in the Civil Engineering Department of the Ohio State University. From June, 1911, until September, 1912, while doing part time work at the University, he was Deputy State Highway Commissioner in charge of the Bureau of Bridges.

Besides being a member of the Ohio Engineering Society, Mr. Morris is also a member of the American Society of Civil Engineers, the American Society for Testing Materials and the Society for the Promotion of Engineering Education.

J. S. McCullough, President Engineering Society of Wisconsin.

J. S. McCullough, president of the Engineering Society of Wisconsin, is City Enginer of Fond du Lac, Wis. His engineering service began as a rodman on the Milwaukee, Lake Shore and Western Railway, which was later absorbed by the Chicago and Northwestern Railway. After 13 years' service with the above companies in various capacities on location, construction, maintenance and office work, he accepted service with the Wisconsin Central Railroad, now part of "Soo Line," on maintenance. He was with the Wisconsin Central five years, during which time second track work and ballasting on southern division was done. He was elected city engineer of Fond du Lac in June, 1908. He served under two mayors under the old aldermanic system, and was retained by the present administration when the city adopted the commission form of government. Since serving as city engineer he has been a member of the Board of Public Works, and up to time of adoption of commission government was president of the board.

He has been a member of Engineering Society of Wisconsin since 1909 and has prepared a number of articles on concrete pavements. Fond du Lac having begun construction of concrete pavements as early as 1908 and having been in a sense one of the pioneers in that type of construction, has resulted in giving Mr. McCullough a wide acquaintance with those in charge of pavement construction.

G. W. Bissell, President Michigan Engineering Society.

George W. Bissell, president of the Michigan Engineering Society, is Dean of Engineering at the Michigan Agricultural College, East Lansing, Mich.

Mr. Bissell has been a member of the society since 1908. He has contributed two papers to its proceedings, as follows: "Some Problems in Engineering Education," and "Deep Well Pumping Machinery." He served for one year on the board of directors before becoming president.

Mr. Bissell was born at Poughkeepsie, N. Y., in July, 1866. He took the course in mechanical engineering at Cornell University and graduated in 1888. He was Professor of Mechanical Engineering at the Iowa State College, Ames, Iowa, from 1892 to 1907, and was Vice-Dean of Engineering from 1904-07. He has been Professor of Mechanical Engineering and Dean of Engineering at the Michigan Agricultural College since 1907. He is a member of the following societies: American Society of Mechanical Engineers, Society for the Promotion of Engineering Education, Society for the Promotion of Industrial Education, and the Detroit Engineering Society

J. S. McCullough
Engineering Society of Wisconsin

George W. Bissell
Michigan Engineering Society

F. W. McKellip, President Minnesota Surveyors' and Engineers' Society.

F. W. McKellip, president of the Minnesota Surveyors' and Engineers' Society, is city engineer of Faribault, Minn. He is a graduate of the engineering department of the Minnesota State University. After several years in railway work, including location on the Kansas City, Mexico and Orient Ry. in Western Mexico and in charge of construction for the Great Northern Railway in Nebraska and Montana, he was elected city engineer of Faribault, which position he has held for the past seven years.

F. W. McKellip
Minnesota Surveyors' and Engineers' Society

He has been a member of the Minnesota Surveyors' and Engineers' Society for two years and has read one paper before the society entitled, "Filing and Indexing of Notes and Records." During 1915 he was a member of the Committee of Municipal Affairs which investigated the law defining the powers and duties of the State Board of Health, with especial regard to the control of water supply and sewage disposal, and urging the appointment of a committee to recommend or draft a law for presentation to the legislature of 1917 granting to the board powers similar to those of the States of New York, New Jersey, Pennsylvania, Ohio and Massachusetts. This recommendation was adopted and a strong committee will have the matter in charge. He was also on the commitee on the League of Minnesota Municipalities (executive board), whose duties were to investigate and report upon a local condition of considerable importance to the Society. Many important matters are to come up before the Society this year, principal among them being the recommendation of changes in the drainage laws and highway laws.

J. H. Felgar
Oklahoma Society of Engineers

J. H. Felgar, President Oklahoma Society of Engineers.

J. H. Felgar, president of the Oklahoma Society of Engineers, is Dean of the College of Engineering of the University of Oklahoma, at Norman. He received his collegiate education at the University of Kansas, getting his A. B. degree in 1901. He finished a course in mechanical engineering at the Armour Institute of Technology, Chicago, in 1905. After graduation he was with the Featherstone Foundry and Machine Co. for some time, leaving them to take up the teaching of mechanical engineering at the Oklahoma Agricultural and Mechanical College. After six months with the Oklahoma Agricultural and Mechanical College he took a position with the University of Oklahoma in mechanical engineering. As stated, he is now Dean of the College of Engineering at the latter institution. He is a charter member of the Oklahoma Society of Engineers, and has continued as an active member since its organization.

H. M. McIntosh, President Vermont Society of Engineers.

Herbert M. McIntosh, president of the Vermont Society of Engineers, is a member of the firm of McIntosh & Crandall, civil engineers and surveyors, of Burlington, Vt. His firm specializes in municipal work with special reference to water works, sewers, roads and streets.

Mr. McIntosh was born in 1861. He attended Castleton Normal School and University of Vermont. He received the degree of C. E. in 1890. He was with the Vermont Marble Co. at Proctor, Vt., 1890-91; in private practice at Burlington, Vt., 1892; was city engineer, Burlington, Vt., 1892-1903 and 1907-1914, and has been a member of the firm of McIntosh & Crandall, Burlington, Vt., from 1905 to date.

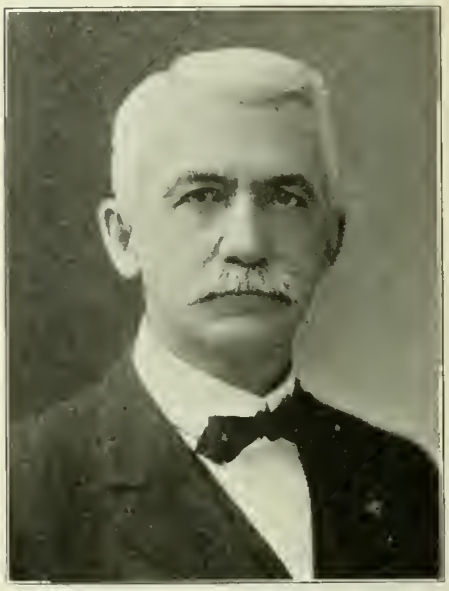
Mr. McIntosh took an active part in the formation of the Vermont Society of Engineers, which was organized in 1912. At that time he served on various committees, among them being the committee which formulated the constitution and by-laws for the Society. Since that time he has served either as a director or as vice president until he was elected president at the last annual meeting.

He is a Vermonter by birth, education and labors, and admits that he has full confidence in the future of the State.

Lawrence W. Wallace, President Indiana Engineering Society.

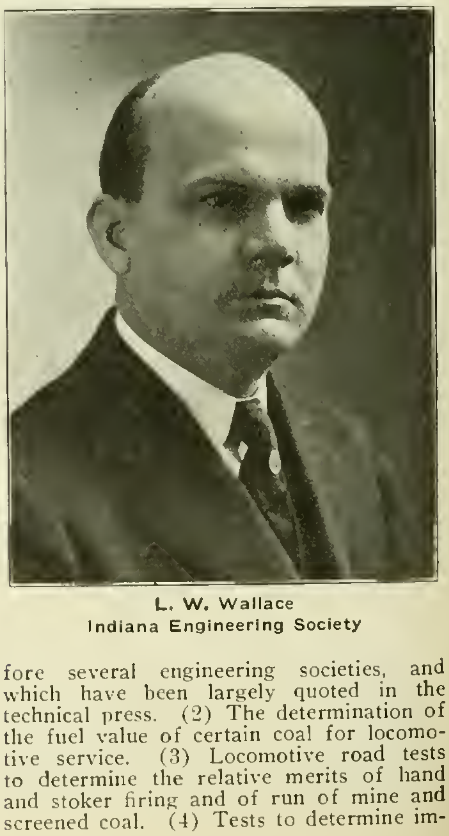
L. W. Wallace, president of the Indiana Engineering Society, is Professor of Railway and Industrial Management in Purdue University, Lafayette, Ind. He was born at Webberville, Texas, in 1881. He attended a country school near Austin and entered the Bastrop High School in 1898, graduating in 1900. In 1900 he entered the Agricultural and Mechanical College of Texas, graduating from that institution in 1903 with the degree of B. S. in mechanical engineering. He obtained his M. E. degree at Purdue in 1912.

In 1903 he entered upon the service of the Gulf, Colorado and Santa Fe Railway Co. at Cleburne, Texas, as a special apprentice, completing the course in 1906. While serving the apprenticeship course he was given many special assignments of an engineering and technical character. He resigned his position with the Santa Fe to accept an instructorship in car and locomotive design at Purdue University. This service began Sept. 1, 1906. During his ten years of service at the University he has been promoted from one position to another, until at present time he is Professor of Railway and Industrial Management. In this position he has full charge of all work done at the University in railway mechanical engineering, which involves control of the M. C. B. air-brake and brake-shoe testing equipment, the locomotive laboratory and other equipment for testing railway devices.


H. M. McIntosh
Vermont Society of Engineers

He has also developed and is responsible for a course in Industrial Management, which is of great importance. In connection with this course the students are assigned definite problems in connection with the operation of actual manufacturing plants.

In addition to actual instructional work he is constantly carrying on experimental work for the university and commercial firms. In the last two or three years he has conducted extensive experiments on the following subjects: (1) Possibility of fire from locomotive sparks; the results of which have been presented in a paper before several engineering societies, and which have been largely quoted in the technical press. (2) The determination of the fuel value of certain coal for locomotive service. (3) Locomotive road tests to determine the relative merits of hand and stoker firing and of run of mine and screened coal. (4) Tests to determine im-


L. W. Wallace
Indiana Engineering Society

pact upon rails due to flat spots on car wheels: an investigation unique in conception and execution. (5) Tests to determine the effect of temperature upon rail breakage. (6) Comparative tests of truck side frames, by use of Berry strain gage. (7) Tests to determine the relative merits of various types of brake linings for automobile and hoisting engine brakes.

Mr. Wallace is a member of the following societies: American Society of Mechanical Engineers, Western Railway Club, American Academy of Social and Political Science, International Railway Fuel Association, Indiana Engineering Society and an associate member of the American Railway Master Car Builders' Association. He has been a member of the Indiana Engineering Society since 1911. He has read the following papers before the society: "Instruction Courses for Railway Apprentices," "Railway Management," "Increased Train Resistance Due to Defective Car Wheels," "Industrial Engineering," "Locomotive Sparks," "Routing—Its Significance."

Paul D. Sargent
Maine Society of Civil Engineers.

He was chairman of the Steam Railway Committee for several years. This committee has submitted a report annually. Previous to his election as president of the Society he was a member of the board of directors.

Paul D. Sargent, President Maine Society of Civil Engineers.

Paul D. Sargent, president of the Maine Society of Civil Engineers, is chief engineer of the Maine State Highway Commission. Mr. Sargent was born in 1873, at Machias, Maine. He attended common schools and high school in that town, leaving high school at end of the third year to enter the Maine State College, now the University of Maine. He graduated from the course in civil engineering in 1896. He had one season's experience in the construction of water works, two seasons in general municipal work at Bar Harbor, Maine; was employed on the survey of portions of the Washington County, Maine, Railroad, and was instrument-man on construction and retained as assistant engineer in the maintenance of way division. Later he was promoted to assistant engineer in charge of maintenance of way division, and was then made engineer, maintenance of way. After five years' experience on the railroad he resumed private practice for two years.

On May 20, 1905, he was appointed State Commissioner of Highways for Maine, being the first appointee to the office. He resigned February 15, 1911, to become assistant director, Office of Public Roads, U. S. Dept. of Agriculture, Washington, D. C. He resigned that position Aug. 1, 1913, to become chief engineer of the highway department of Maine under a reorganization, with a three-headed commission, which position Mr. Sargent has since held.

Mr. Sargent was active in the organization of the Maine Society of Civil Engineers, which held its meeting for organization at the offices of the State Highway Department, State Capital, in February, 1911, just prior to his leaving for Washington. At that time he was elected to the board of directors. He dropped out of the active management of this association during his residence in Washington, but resumed the same upon his return to Maine and at the first annual meeting after his return was elected vice president of the society.

Under Mr. Sargent's direction all of the investigation work with respect to the condition of Maine highways has been carried out, and while in the employ of the government he was consulted more or less with respect to the highway situation in Maine. The Maine Highway Commission has laid out a system of State highways of about 1300 miles, which is 5 per cent of the total road mileage of the State. This system passes through cities and towns wherein is found 73 per cent of the valuation of the State and 73 per cent of the State's population. A system of State aid roads is being constructed at the same time to act as feeders for the State highways. Expenditures for State highway work amount to $500,000 per year and for State aid highways the State appropriates $300,000 and the cities and towns furnish a like amount. State and State aid highways are maintained by the highway commission and during 1915 the State expended on this account about $120,000 and the cities and towns about $45,000. All special road and bridge resolves of the Legislature are placed under the care of the State Highway Commission. The annual expenditures of the commission are a little in excess of $1,500,000.

William S. Turner, President Oregon Society of Engineers.

William S. Turner, president of the Oregon Society of Engineers, is a consulting engineer with offices in Portland. He was born at Quincy, Ill., in 1858. He took the four-year scientific course in Knox College and took his B. S. degree in 1879. He took a two-year post-graduate course at Cornell University in electrical and mechanical engineering and took his M. S. degree in 1886. He joined the American Institute of Electrical Engineers in 1887.

In 1886-7 he was construction foreman of electric lighting with the Westinghouse Co. In 1887-8 he was with the Edison Electric Co. and was engaged in the design of a central lighting station and the supervision of the installation of underground conduit and cables in New York.

From 1888-98 he was an engineer and contractor of New York City and superintendent or directed the construction of the power plant and trolley systems of the following corporations and cities: Augusta, Ga.; Chattanooga Elevated Street Railway; Quincy, Ill.; South Nashville, Tenn.; Washington & Arlington Ry., D. C.; Amsterdam & Rockton St. Ry., N. Y., and Wilmington, Del. Similarly he had charge of the following trolley system constructions: Brooklyn & Jamaicia Ry., N. Y.; Coney Island & Brooklyn R. R., N. Y.; East Reading R. R., Pa.; Naumkeag Street Ry. Co., Salem, Mass.; Poughkeepsie, N. Y.; Troy & Lansingburg Street Ry.; Union R. R. Co., Providence, R. I.; Chester, Pa.; Paterson, N. J.; Portland, Me.; Scranton & Pittston Traction Co.; Capital Ry. Co., Washington, D. C. He also installed the Mt. Vernon, N. Y., telephone system. Only the principal engagements during this period are here enumerated.

From 1899 to 1908 Mr. Turner was with the J. G. White Co. of New York. In 1899-1900 he was resident engineer on street railway construction in Elizabeth, N. J., and Winston-Salem, N. C. At the latter place a lighting system and ice plant were also installed. In 1900 he was also construction superintendent on the Washington & Glen Echo R. R. at Washington, D. C., and portions of the Brightwood Railway and other suburban line construction work. In 1901 he was construction superintendent on high tension transmission line work. In 1901-4 he was managing engineer in Aukland, New Zealand, on 30 miles of electric tramway construction. This work included grading, paving, trolley, underground conduits and cables, power plant, 43 cars and motor equipment. In 1904 he was resident engineer on the construction of the Youngstown, Ohio, & Southerland Ry. In 1905 he was similarly engaged on interurban lines at East St. Louis, Ill. A part of 1905 and all of 1906 he spent in the New York office of the J. G. White Co., reporting, designing and estimating costs on engineering projects, and in charge of contracts, cost reports and accounts. In 1907 he was resident engineer at Boone, Ia., on the electrification of the Ft. Dodge, Des Moines & Southern R. R., a 100-mile project.

W. S. Turner
Oregon Society of Engineers.

In 1908-10 he was managing engineer of the Northwestern office of W. S. Barstow & Co., at Portland, Ore. He had charge of the construction of the Oregon Electric Railway, from surveys to equipment. He also had charge of the design and construction of a complete system of underground conduits and cables for electric light for the Portland Railway Light & Power Co. in the business section of Portland.

From 1911 to date Mr. Turner has been a consulting engineer at Portland, Ore. He specializes in designing and supervising the construction of electric railways, lighting and power plants, hydro-electric plants and water works. He also makes valuations, investigations, financial reports, etc.

Mr. Turner was a charter member of the Oregon Society of Engineers, which was organized in 1911, was elected vice president in 1912 and served three years in that office. He was elected president in February, 1915. He has served on numerous committees most of the time.

M. G. Hall, President Iowa Engineering Society.

M. G. Hall, president of the Iowa Engineering Society, is a consulting civil and sanitary engineer with offices at Centerville, Iowa. Mr. Hall was born at Baraboo, Wis., in 1877, attended the public schools of that city and spent three years at Laurence College in Appleton, Wis. He graduated from the University of Wisconsin in 1904. His special work at the university was along the line of municipal and sanitary engineering.

From 1904 to 1906 he was in the employ of the Iowa Engineering Co. of Clinton, Ia., as resident engineer on sewer and street paving construction at Atlantic, Ia.; Laurel, Miss., and Centerville, Ia. From 1907 to 1910 he was city engineer of Centerville and engaged in private practice in municipal work in surrounding cities and towns. From 1910 to the present time he has engaged in private practice exclusively.

During the past few years he has handled a large volume of work as follows: Sewers, $322,700; water works, $198,000; water purification, $35,000; sewage disposal, $88,800; street pavements, $951,000; miscellaneous, $80,000. These works have been designed in his office and constructed under his supervision. He has also reported on additional projects estimated to cost, in the aggregate, $470,000.

Samuel Young
Louisiana Engineering Society.

Mr. Hall has been a member of the Iowa Engineering Society for ten years. He was a director of the society in 1914 and vice president in 1915. He is also a member of the Western Society of Engineers and of the New England Water Works Association. He has been active in committee work.

Samuel Young, President Louisiana Engineering Society.

Samuel Young, president of the Louisiana Engineering Society, is a member of the firm of Guerin & Young, consulting engineers, New Orleans, La. He graduated from Washington & Lee University in 1898 with the degree of Civil Engineer. From the University he went to New York State where he was employed for several months on topographic surveys being made by the U. S. Deep Waterways Commission along the route afterward adopted for the Barge Canal. Then followed about three years of railroad location and construction in Arkansas, Oklahoma and Texas, during which time he advanced from rodman to transitman on location and resident engineer on construction. For the next three or four years he was superintendent for a contractor who was engaged in the construction of electric railways, water supply and electric lighting plants and sewers. Then came two years of railroad work, during which time he located and built a portion of the New Orleans Great Northern R. R. in Louisiana and Mississippi and afterward, as division engineer, had charge of track laying and ballasting of this road. For about three years following this railroad work he was associated with Mr. J. F. Coleman, Mem. Am. Soc. C. E., consulting engineer of New Orleans, and was for two years a member of the firm of J. F. Coleman & Co.

Since 1912 he has been associated with Mr. L. H. Guerin in general practice of civil engineering, during two years of which time he was chief engineer of the Board of Commissioners of the Port of New Orleans.

R. Boone Abbott, President Engineers' Society of Pennsylvania.

R. Boone Abbott, president of the Engineers' Society of Pennsylvania, is superintendent of the Harrisburg division of the Philadelphia & Reading Railway Co.

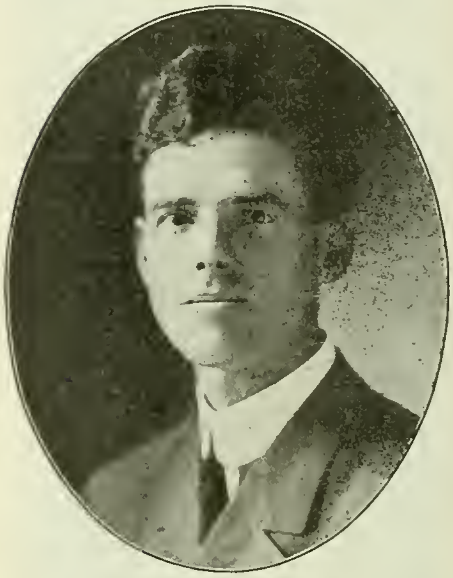
Mr. Abbott was born at Philadelphia in 1881. He was educated in the public schools of Atlantic City, N. J., and Pottsville, Pa., being a graduate of the latter. After taking a portion of a post-graduate course in higher mathematics he entered the division engineer's office of the Philadelphia & Reading Railway at Tamaqua, Pa., in October, 1900. During subsequent years he filled in the order named the following positions on the Philadelphia & Reading Railway; assistant supervisor at Tamaqua, Milton, Reading and Harrisburg, Pa.: supervisor at Allentown, Olney and Pottsville, Pa.; division engineer at Harrisburg, Pa.; division superintendent at Tamaqua and Harrisburg. He was appointed to the latter position March 29, 1916.

During the years 1913, 14 and 15 he was treasurer of the Engineers' Society of Pennsylvania. He is a member of the American Railway Engineering Association and has served for three years on Committee No. 9.

Jay W. Bliss, President North Dakota Society of Engineers.

Jay W. Bliss, president of the North Dakota Society of Engineers, is State Engineer of North Dakota. He was born in 1885 at Harrisburg, Dakota Territory. He attended county schools, later graduating from the Lakota High School and receiving his degree in mining engineering at the University of North Dakota in 1908. He spent his vacations in Idaho and Washington, working in various mines.

In 1908 Mr. Bliss secured a position in the North Dakota state engineer's office as assistant mine inspector, the state engineer being ex-officio state mine inspector. He remained in the employ of the state engineer's department until the spring of 1913, when the state engineer retired. Mr. Bliss administered the affairs of the office under executive direction for some months, after which he was appointed as state engineer.



J. W. Bliss
North Dakota Society of Engineers.

Mr. Bliss was admitted to the North Dakota Society of Engineers in February, 1913, since which time he has served on the committee on irrigation and rivers and the committee on legislation. He has presented the following papers before the society: "State Coal Mine Inspection," "Irrigation in North Dakota" and "State and County Roads." He was elected first vice president in 1915, and at the 1916 meeting of the society he was made president.

$6,000,000 Bond Issue Voted for Rapid Transit Lines at Cincinnati.

The citizens of Cincinnati, O., on April 25 authorized the issuance of $6,000,000 of bonds for a municipal rapid transit development. The scheme, in brief, provides for the construction of a belt-line railway around the city and the erection of a terminal station for the entrance of interurban lines into the business district.

The plan provides for a standard gage double track line, connecting the various suburbs of the city. The total ultimate length of the proposed railway is 15.56 miles, of which 6½ miles will be in subway, 0.63 mile in tunnels and 8.43 miles in the open. In the open work there will be 20 bridges with a total length of 2,200 ft., and 6,100 ft. of concrete trestle around the Ohio River bluff. The line follows the old Miami and Erie Canal for a considerable distance.

Frank S. Krug, city engineer of Cincinnati, O., has been appointed administrative head of the municipal rapid transit scheme. He also is chief engineer of the commission and will have charge of the actual constructive work.

Excavation and Concrete Work for U. S. Reclamation Service.

Three good sized construction jobs are being advertised for bids by the U. S. Reclamation Service. One of these is the first tunnel work of any size that has come up for letting by the service for some months. This work calls for the construction of two tunnels and concrete lining of canal approaches to same on the Fort Laramie Canal of the North Platte Project. The undertaking calls for about 4,850 lin. ft. of tunnel excavation and 12,000 cu. yds. of concrete. The work is situated near the Bridgeport-Guernsey line of the Chicago, Burlington & Quincy Ry. in the vicinity of Fort Laramie, Wyo. Bids will be received at the Fort Laramie office of the Reclamation Service until 2 p. m., May 22.

Bids also will be opened at Fort Laramie, Wyo., on May 25, for the earthwork on about 8½ miles of main canal of the Fort Laramie unit of the North Platte Project. This work calls for about 793,000 cu. yds. of excavation. It is situated near the Bridgeport-Guernsey line of the C., B. & Q. Ry. in the vicinity of Fort Laramie.

The other job on which bids are now being asked by the U. S. Reclamation Service calls for the construction of canals and structure on the Flathead project, Montana. It involves about 220,000 cu. yds. of excavation, 870 cu. yds. of reinforced concrete, 3,250 sq. yds. of paving, 7,550 sq. ft. of canal lining, manufacturing and laying 6,230 lin. ft. of concrete pipe, laying 210 cu. yds. of dry rubble wall, erecting 4,000 ft. B. M. of lumber and placing 110,000 lbs. of structural and reinforcing steel. The work under Schedules 1 and 2 is located from 3 miles to 10 miles southwest of Polson, Mont., and the work under Schedules 3 and 4 is located from 6 miles to 8 miles west of Ronan, Mont. Bids will be received until 2 p. m., May 25, at the office of the U. S. Reclamation Service, St. Ignatius, Mont.

Engineering and Contracting

Devoted to the Economics of Civil Engineering Design
and to Methods and Cost of Construction

EDITORS

H. P. Gillette | C. S. Hill | C. T. Murray | S. C. Hadden | C. W. Malcolm

Volume XLV. CHICAGO, ILL., MAY 10, 1916. Number 19.

Twenty-Five Dollars Monthly in Bonuses

First $12 Second $8 Third $5

¶ Shor. stories containing usable suggestions are wanted for our department entitled *Current Engineering Practice Briefly Recorded.* (See issue of May 3, 1916.)

¶ The character of article wanted is a plain, practical description of some simple and efficient structural detail or construction method, device or tool. Give costs if possible; provide sketches*, prints or photographs if practicable.

¶ *For all articles* published payment will be made at space rates.

¶ In addition, for the three articles ranking, in the opinion of the judges, first, second and third in order of merit, there will be awarded the bonuses stated above.

Instructions

(1) Articles must not exceed 500 words.

(2) As many articles as desired may be submitted by the same person.

(3) Awards will be to articles, not to persons, so it may happen that one person will receive all three bonuses.

(4) Contributors need not be subscribers.

(5) Literary excellence will not determine merit.

(6) Name, position or rank will not influence awards.

(7) Contest for May closes May 31.

(8) Awards announced June 7.

* Rough free-hand sketches that convey the principle w suffice. They can be perfected by our drafting department.

Get Busy and Get a Bonus

CONSTRUCTION PROCESSES PROPERLY INCLUDED IN SUBGRADE PREPARATION.

Subgrade preparation is not a term having definite meaning in concrete road construction. Properly it should mean only the surfacing and finishing of the graded roadbed. It is an operation made up of substantially superficial earthworking processes. Substantially superficial is again a term having indefinite meaning. Since some specific dimension seems necessary, a thickness of 3 in. of the top of the roadbed is arbitrarily assumed to be the limit of true subgrading operations. All deeper working of the soil in preparing the roadbed is classified as grading. Subgrade preparation, then, includes final finishing of the graded roadbed to exact transverse and longitudinal profile and working this shaped surface to uniform firmness and to a reasonable degree of smoothness.

The main concept of shaping subgrade is form or surface outline. Primarily, shaping subgrade is working the top soil to exact lines and surfaces by scraping and smoothing processes. A secondary purpose is, while so working the soil to form, to prepare the soil so that it will compact uniformly. Shaping operations, therefore, include processes for pulverizing the soil, for mixing soils of different qualities, and for excluding materials incapable of homogeneous incorporation with the prevailing material. Previous selective work in the grading operations has to a great degree prepared the surface soil properly and necessity of some further selection and working always remains to be disclosed by the test of rolling, but in shaping subgrade is involved the finer preparation of the surface soil to compact uniformly.

A clear understanding of the fact stated is important. It serves little purpose to bring a subgrade surface to perfect shape if the subsequent rolling turns it into a series of hillocks and hollows because the top soil is not sufficiently homogeneous in composition to compact uniformly. Subgrade shaping operations, it will be repeated, include loosening, mixing and pulverizing processes to insure uniform compacting. The depth of such manipulation, if the grading has been properly performed, is small; the extent to which it is necessary depends upon the character of the roadbed surface material. Shaping subgrade, to summarize, comprehends the task of forming the top of the roadbed to exact profile of a material which will compact uniformly.

Compacting the shaped subgrade is the concluding process of subgrade preparation. The extent of the operation varies with practice. Uniform density of subgrade is a requisite upon which road builders are in accord. There is, however, disagreement concerning the degree of density advisable. Some advocate as extreme hardness as the material will permit being obtained. Others would confine the rolling process to not much more than an ironing out of the surface to eliminate the looseness of the top soil. Still others advocate the use of a cushion layer of selected material on a hard rolled grade. Obviously the extent of the compacting operations and in some respects their nature, depend upon the practice followed in respect to density and to consistency or subbase. Invariably the compacting method is rolling.

The processes outlined are exactly in nature the processes employed in grading. In fact the plane of demarkation between grading and subgrade preparation is not clearly defined so far as construction processes are concerned. Constructionally subgrading is the final process of grading operations. It is, however, something more than this; it is an extra process whose necessary performance is contingent upon subsequent pavement laying. Herein is the reason why this separate recording is necessary, and if this separate recording is to be at all exact definite arbitrary limits must be named. This brief discourse is a suggestion toward definition of such limits.

THE MAKINGS OF A GOOD CONTRACTING FIRM.

Occasionally we read that an engineer and a contractor have formed a company to engage in the contracting business. Very likely such firms are frequently formed and others might well be. An engineer and a contractor, each of the right kind, make a strong contracting combination. The editor has long been interested in this subject. Some years ago, while practicing engineering, he had an opportunity to cast his lot with a contractor but, for better or for worse, declined to do so. The wisdom of his decision is still in question.

The ability to get along well together is the first essential requirement to a successful partnership. The engineer and the contractor can easily test each other out in this particular. If the supervising engineer on a contract job gets along well with the contractor when their interests frequently appear to conflict, it is a moral certainty that they will get along well when their interests become identical. It is under these circumstances that engineers and contractors are thrown together, become acquainted and form partnerships.

In this discussion we are conforming to accepted usage of the words engineer and contractor. The engineer is really a designing and supervising engineer, and the contractor is in reality a construction engineer. Each often possesses attributes, training and experience that the other lacks, so when united they form a well rounded working unit.

Many engineers and contractors can better themselves by taking the step here discussed. Why not make a study of the other half of the sketch, during the present construction season, with a view to the formation of such a firm?

CENSUS BUREAU ISSUES VALUABLE WATER WORKS DATA.

Very full and complete data relative to the municipally owned water works in cities having a population of over 30,000 in 1915 are given in the recent Bureau of the Census report entitled: General Statistics of Cities: 1915.

In brief, data and descriptive matter on the following subjects are given: Number of cities owning water supply systems and year of completion or purchase of original plant; estimated value of municipally owned water supply systems; sources of water supply; reservoirs and standpipes; wells; power and pumps; purification; purification processes; quantities treated; cost of purification; sources of water supply of cities having purification systems; growth and progress of purification shown by installation of systems in the different years; sources of water supply of cities having no purification system; distribution equipment of water supply systems; per cent of water metered; water supplied to systems during the year; population served and per capita daily consumption; and, estimated value of system. The flat and meter rates in vogue in all these cities are given.

These data are of the kind which are collected by committees of the water works associations and are much more complete than any committee has ever succeeded in securing. They are of great value to all water works engineers and to all operators who have more than a one-town interest in the water works business.

CULTIVATING HIS HONOR THE MAYOR.

Engineers will do well to cultivate the mayor. Lest it be supposed that we use the word cultivate in the sense of seeking society or courting intimacy, we shall be at some pains to point out other shades of meaning which are pertinent to this discussion. Thus, according to Webster, the word cultivate has three meanings other than that already mentioned: (1) To bestow attention, care and labor upon, with a view to valuable returns. Engineers are far from being unskilled in this form of cultivation. (2) To direct special attention to; to devote time and thought to; to foster. That is, take the mayor while he is young and impressionable and bring him up in the way he should go. (3) To improve by labor, care, or study; to impart culture to; to civilize; to refine. Number three merits a full discussion.

Our attention was drawn to this subject at this time by the announcement that the Akron, Ohio, Technology Club of the Massachusetts Institute of Technology has tendered its services to the mayor of that city. This action was taken very recently, but already worth-while results have been secured. Our informant states that he believes a great amount of good can be done municipalities if citizens who have the proper training and ability will get behind their executive officer and help him over some of the rough places connected with his work. In other words, a local engineering society can accomplish much by acting unofficially in an advisory capacity. Many mayors welcome this form of advice. Even though tarred with the political stick, the average mayor is anxious to do his best most of the time at the very least.

It is a good plan to invite the mayor to attend engineering society banquets and smokers. Usually he will frankly state his engineering perplexities in the unrestrained atmosphere peculiar to such functions, and will welcome suggestions from those who have special knowledge as to the best way of handling the engineering problems with which he is confronted. Obviously this free and informal technical advice will not supplant that formally given in exchange for a fee. On the contrary, the informal advice will oftentimes make clear to the mayor the desirability of obtaining formal advice.

We repeat: Engineers should cultivate the mayor. It won't hurt them and it is practically certain to benefit him and the city.

EVIDENCE THAT REINFORCEMENT PREVENTS CRACKING OF CONCRETE PAVEMENT.

Reinforcement of all concrete pavement is, in the opinion of many engineers, warranted because of the insurance it furnishes against cracking. Much sound theory is voiced in support of the conviction that reinforcement is a crack preventive, but equally sound evidence has been wanting. Where reinforced concrete pavements have not cracked the conviction is not certain that a plain slab would not have remained equally unbroken. It is interesting, therefore, to note the following curious bit of evidence: In Lake County, Ohio, the Madison South Ridge road, 5.43 miles of 16-ft. slab divided into 33⅓-ft. blocks, had 90 scattered blocks reinforced. According to statement of H. P. Cummings, Lake County surveyor, one can follow throughout this road a longitudinal crack block after block until a block that was reinforced is met and here the crack ceases, to begin again after the reinforced slab is passed. In this example there would seem to be a direct comparison, in respect to safety from cracking, of plain and reinforced concrete pavement.

SUN SPOTS AND THE WEATHER.

The hypothesis was long ago formulated that there is a definite relation between the so-called sun spots and the weather. The hypothesis now bids fair to become a well-established theory. Prof. Willis Luther Moore, formerly chief of the U. S. Weather Bureau, is authority for the statement that W. F. Carothers "has undoubtedly discovered the central law of the weather," and he says that it will hereafter be possible to predict the weather two weeks in advance more accurately than it has been hitherto possible to predict two days in advance.

There are rifts in the sun's photosphere—or sun spots—through which emanates greater heat than from the photosphere or gaseous envelope itself. The sun revolves about its axis in 25 days—not 27, as was formerly believed—and, as the rifts change slowly, they reappear in the same relative position every 25 days. The greater heat emanation that occurs from a rift raises the temperature of the air near the earth's equator more than in higher latitudes. The expanded air bulges upward until finally masses of it break loose and slide toward the poles. These masses, converging as they near the poles, cool and sink to the earth, settling over continents in winter and over oceans in summer. The air masses rotate as they descend and cause ascending cyclonic storms on both their eastern and western sides, and produce rain by forcing upward the warm, moist air in the cyclonic centers.

Having located one or more heat rifts in the sun, a cold wave may be expected to follow three weeks later in the western part of America.

Nearly three years ago we made editorial comment upon the discovery that the thickness of the rings of the giant redwoods of California had been found to show a periodic (11-year) variation that accorded with variations in the intensity of the sun spots. The latest discoveries of Carothers and Moore bear out the correctness of the earlier inferences that both the quantity and the time of rain precipitation are largely affected by the spots on the sun.

EDITORIAL PARAGRAPHS.

The steel industry is one industry in which for nearly ten years the only change in wages has been a movement upward. These advances have been as follows:

Jan. 1, 1907	7 per cent
Jan. 16, 1910	6¼ per cent
Feb. 1, 1913	10 per cent
Feb. 1, 1916	10 per cent
May 1, 1916	10 per cent

As in each case the percentage of increase has been applied upon the rates in effect at the time, the total increase since Jan. 1, 1907, has been 43¼ per cent.

The river and harbor bill carrying an appropriation of $39,600,000 has passed the House of Representatives, and thus tradition is upheld. But the vote against river and harbor appropriations in the House has increased every year for three years and this year was greater than ever —143 votes against and 159 votes for a $20,000,000 substitute. A few years will see necessary river and harbor improvements planned and conducted with some approach to intelligence and economy.

While having waterways in mind let us note that the state of Illinois cannot secure the right to build one at its own expense while other projects manyfold less deserving are richly provided for by a generous Federal Congress. Incidentally it is an Illinois man, a real waterways engineer, Mr. Isham Randolph, who proposed some years ago and is still advocating a Federal Department of Public Works. Some day the people will experience an "ecstasy of common sense" and there will be such a department created.

Contractors' equipment at the end of a job, is usually in need of thorough overhauling. The proper time to put it in shape for the next job is not after the next job has been secured but immediately after the last job has been finished. A part of the overhauling should usually include repainting. Who has not seen "wheelers" and other equipment rust out when idle faster than they wore out in service?

The use of billing machines and a piece-rate payment (90 cts. per 100 tallies) effected a saving of nearly $8,000 in 1915 at the Burr Oak (Chicago) transfer station of C. R. I. & P. Incidentally we may add that the use of such special typewriting machines in accounting and billing work makes it easier to keep records of the units of work done, and this, in turn, favors the introduction of a piece-rate or bonus payment system.

An illuminating sidelight on the capacity of ordinary good roads to withstand military traffic is furnished by the news bulletin of the Pennsylvania Highway Department. The bulletin says:

> During the last season several companies of light artillery passed over one of the state highways in the central part of Pennsylvania. This road had been placed in shape by the Maintenance Division of the State Highway Department and was, for the ordinary vehicular traffic, a boulevard. After the passage of the artillery corps, the road was heavily rutted and its utility as a means of intercommunication virtually destroyed. The state highways, leading to the United States ranges in Pennsylvania, while capable of withstanding all of the automobile and horse-drawn traffic passing through the region, go to pieces rapidly under the artillery traffic connected with the ranges. One reason for this is that military traffic moves along the highways with military precision, each article of equipment following exactly in the trail of the one preceding it.

WATER SUPPLY FOR CONCRETE PAVEMENT CONSTRUCTION.

Water is required in concrete pavement construction for sprinkling subgrade, for mixing concrete, and for curing laid pavement. Chances of miscalculation are as great in the matter of water supply as in any item of the concrete work. Usually it is the quantity required that is underestimated, but location of supplies, means for adequate conveyance, pumps, and pumping costs are carelessly calculated. A well considered and definitely planned water supply is as essential as is a similarly planned cement, sand, and stone supply.

Quantity of Water.—The quantity of water required varies with the character and condition of the aggregates, with the consistency of the mixture employed, with the character and condition of the subgrade soil, with the method and period of curing, and with the weather conditions. The variation in water consumption as influenced by consistency and by the character and condition of the raw materials is discussed at length in the standard treatises on concrete. Here only the main influences are noted. Fine cement requires more water than does coarse cement; fine aggregates require more water than do coarse aggregates; dusty aggregates require more water than do clean aggregates; porous aggregates require more water than do those composed of dense-textured stone; dry aggregates require more water than do those containing natural moisture. Generally speaking, gravel aggregate requires less water than does broken stone aggregate, since it has more natural moisture, is more dense and contains less dust. A mixture rich in cement requires more water than one with less cement. Obviously a wet mixture requires more water than does a dry mixture, and practice in road construction varies greatly in respect to wetness of mixture employed. All influences, as named, considered, a cubic yard of road concrete as discharged from the mixer will have consumed from 18 gal. to 35 gal. of water. The extreme consumption will seldom exceed 50 gal. per cubic yard.

Character and construction of subgrade soil, method and period of curing laid pavement and weather conditions affect the water consumption. If the soil is thoroughly dried more water is required than if it is moist. A porous soil that drains quickly requires more water than a dense, retentive soil. The curing process employed and the length of the curing period influence the water consumption. Dry, warm weather increases the evaporation, and so the amount of water required for keeping wet subgrade and laid pavement. Cool, wet weather reduces evaporation and supplies some or all of the water required for wetting. Under normal conditions water consumption for wetting subgrade and curing laid pavement will be double the amount required for mixing concrete; under extreme conditions it has exceeded three times this amount.

Estimating the quantity of water required for concrete paving is an uncertain task; no definite rules have been formulated and few exact figures of actual consumption have been recorded. W. A. Gillette, experienced in road building in southern California, states: "It will be necessary to operate a pump of 50 gal. per minute capacity, 12 to 14 hours, in order to supply the mixer and wet the concrete during the day and wet the subgrade after the mixer shuts down each day." This statement means, roughly, from 35,000 to 40,000 gal. water consumption per day, or, on a basis of 140 cu. yd. mixed per day, a consumption of 250 gal. per cubic yard of concrete laid. This quantity may probably be considered about maximum for concrete paving. C. H. Moorefield and J. T. Voshell of the Office of Public Roads state that a mixer gang consuming 320 bbl. cement, 70 cu. yd. sand, and 140 cu. yd. coarse aggregate per day will require 8,800 gal. of water for mixing and 10,000 gal. more for keeping wet, for two weeks, laid pavement. They consider that the pumping plant should be capable of supplying 25,000 gal. per 10-hour day. C. D. Franks, speaking of road work in Indiana, states: "The sprinkling of subgrade before concrete is laid, the mixing of the concrete and the sprinkling of the finished concrete for curing will require an average of 13,000 gal. per day, when 500 sq. yd. of concrete are laid." He considers that "it is unsafe to provide for any smaller amount than 25 to 30 gal. per square yard of concrete laid." On the basis of a 6-in. pavement, this is 150 to 180 gal. per cubic yard. It is probable that these quantities represent approximately the safe minimum required water supply.

Sources of Supply.—In town work or work adjacent to towns having a public water works the natural source of supply is the town supply. Factors that have to be considered in selecting town supply are the rates charged, the pressure available, and the investment required to make the supply available at the work. If the pressure is small a booster pump may be necessary to get the needed flow at the end of a pipe line of the length required. This expense added to the rates charged and perhaps the need of greater length of pipe may easily make it less expensive to install an independent supply from a local stream or pond. A draft of 15,000 to 25,000 gal. per day on a small town water supply may readily be more than the plant will handle.

On country road construction the local streams are the only sources ordinarily, and in streamless country it may be required to sink wells. Here, again, a factor which must not be overlooked is the adequacy of the supply. Many streams become dry in summer or run so low that ponding is necessary. Survey of local stream sources must, therefore, include investigation of their permanency of flow; it may be cheaper in the end to go farther to secure an unfailing source than to select a nearer source which may later have to be abandoned or will hamper concreting because of lack of water. Another matter to be considered in alternative selection of sources is the relative lift and distance that have to be pumped against. A near source with a high lift may be less economic than a far source with a low lift. Too great refinement of comparative study is unwarranted, but neglect to consider alternative sources may easily make the cost of water greater than need be.

Conveyance of Water.—Hauling water in tanks is a contingency that should not be considered unless necessity compels. A moderate supply of 15,000 gal. per day means hauling 62½ tons of water, and tank wagon haulage will seldom cost less than 25 ct. per ton-mile. In addition to cost of hauling, water can seldom be conveniently applied from tank wagons.

Pipe line conveyance is most economical. In planning pipe lines a number of considerations need to be taken into account. Ordinarily a single pipe line only is employed, but the plan of having two pipe lines is being seriously considered by some experienced road contractors. The reason urged for the double line is that with a single line, particularly where the pressure is low, serious mixer delays result from stoppage of flow at the mixer when water is drawn for sprinkling laid pavement or for other purposes. With two pipe lines, one supplies the mixer and one is for general use. Practice is in accord that, except temporarily until larger pipe can be selected, smaller than 2-in. pipe should not be employed. The friction in pipes increases as the square of the velocity, and for the same discharge the friction head against the pump is much greater with a small pipe. No smaller than 2-in. pipe with 2-in. connections is advisable.

Too exact precision in pipe line gradient and alignment is unnecessary, but readily avoidable sags and bends should not exist; each such bend increases the friction head. Flanged unions and gate valves should be inserted about every 500 ft. to permit sections of pipe to be taken out for removal of obstructions or for other purposes. At intervals of 200 ft. tees and taps should be inserted. The tees should be 2-in. with 1-in. taps for hose attachment. With taps spaced 200 ft., a 100-ft. hose will reach all parts of the road. A hose longer than 100 ft. and smaller than 1-in. is inadvisable. Other pipe line appurtenances required, if the line is of considerable length, are relief valves and expansion joints. An easily field handled relief and one which also serves somewhat as a pressure regulator consists of a 2-in. tee near the mixer, from the nipple of which is erected vertically a length of pipe, open at the top. This stand pipe is shifted so as always to be in the vicinity of the concrete laying. Various forms of expansion joints are on the market, but three or four elbows and some short lengths of pipe permit the construction in the pine line of a U or a V which will handle expansion and contraction. Another good construction is to connect two adjoining lengths of pipe with a piece of hose, setting the pipe ends some 6 in. apart and using hose of the same size as the pipe. The spacing of expansion joints should not exceed, ordinarily, 2,000 ft. Under favorable conditions, with the pipe distributed, four men will lay from 1,000 ft. to 1,500 ft. of new pipe line per day. Used pipe, because the threads are somewhat battered, is laid with less speed; probably 600 ft. to 800 ft. per day with four men is a fair record.

Pumps.—The friction and static heads in road work pipe lines are considerable, and considerable pressure at the taps is required for effective use of water. A high pressure pump of good quality and capacity is demanded. Common mistakes are pumps either too small or of cheap quality. Practice in the matter of size of pumps shows wide extremes. The arrangement of plant is in practice almost as varied. To give from practice definite directions for pump selection and installation is impracticable; yet the examples thus furnished are about the best sources of information available.

Based on concrete road construction experience in southern California, W. A. Gillette outlines the following practice: First, pump from source to storage tank and from tank by higher pressure pump into pipe line. When the source is a well use a lifting pump of about 60 to 80 gal. per minute capacity, operated by a 4-hp. gasoline engine. Pumps of this type are constructed with gears operating an eccentric which drives the pump rod, the piston being submerged. A double action piston is the best. If water is taken from a stream, use a small centrifugal pump, operated by a 4-hp. gasoline engine. Preliminary pumping to storage tank is particularly necessary when pumping from stream or pool, as in the tank the sand settles and only clean water is furnished to the high pressure pump. This is an important requisite, for it takes very little sand to score the cylinders of a high pressure pump enough to make them useless. A tank capacity of 1,000 to 2,000 gal. is ordinarily ample. In selecting the high pressure pump ensure ample size. Theoretical capacities computed from engineers' formulas are practically inadequate. A satisfactory pump for road work is 4x6 in., 350 lb. pressure pump. Such a pump will deliver 50 gal. per minute through a 2-in. pipe line 5 miles long with a head of 250 ft.

The pumping plant described is more than ordinarily elaborate. Usually the arrangement is one by which the high pressure pump draws directly from the stream or pool. In such case care is necessary to fit the suction pipe with strainers to exclude coarse debris and also to arrange the suction pipe and sump so as to exclude as much as possible sand and silt. A little reasonable care in these features will be repaid in decreased pump repairs and in freedom from clogged pipe lines. Ordinarily also it is worth the extra engine cost to have a little surplus engine power; a 5 or 6 h.p. gasoline engine is a better all-around engine than one of 4 h.p.

Cost of Water Supply.—Definite recorded costs of water for concrete road construction are scarce. The records available are, however, worth brief citation because there is nothing better. On the 14-mile state road from Healdsburg to Santa Rose, California, the water cost for wetting subgrade, mixing concrete and curing laid pavement was $18.40 per day and the average daily run of concrete laid was about 102 cu. yd., which makes the cost of water about 18 ct. per cubic yard. As reported by C. L. Rakestraw, resident engineer, the conditions and costs were as follows: A line of 2-in. boiler pipe in 8-ft. lengths was laid along the work and provided with 1 in. taps at 50-ft. intervals. This pipe line was torn up and relaid as the work progressed; two men at a daily cost of $5 were employed continuously at this work. In one case a well 180 ft. deep costing $380 was driven, but all other stations were at adjacent streams. The cost per day of supplying water was itemized as follows:

1 gas engine pumpman at $2.75	$ 2.75
2 gas engine pumpmen at $2.50	5.00
2 pipe layers at $2.50	5.00
Interest and depreciation on 17,000 ft. pipe and engine	2.00
Fuel and oil	2.15
Superintendence	1.50
Total	$18.40

It was figured that about equal quantities of water were used for subgrade, for mixing and for curing.

The following costs are estimated from partial records: On road in Ada County, Idaho, one water team and man is recorded as costing $7.25 per day and average daily output as being 600 sq. yd. of 7-in. pavement; these figures give a cost for water of 1.2 ct. per square yard or about 6 ct. per cubic yard of concrete. On roadwork in Jackson County, Oregon, cost for one month of pumping and laying water pipe is given as $333.89 and the concrete laid as about 1,820 cu. yd., making the water cost something in excess of 18 ct. per cubic yard of concrete. On road work in the San Joaquin Valley, California, cost of pumping alone for a record day is given as $6 and the concrete laid as 159 cu. yd., giving a cost for water of 3.7 ct. per cubic yard. On average days about 90 cu. yd. were laid which at the same pumping cost per day would be 6½ ct. per cubic yard for water. The wide extremes of recorded water costs for concrete road building emphasize the necessity of specific estimates of this expense for each contract. The cost of water supply is always something. Even in city work where water is delivered free at hydrant there is the expense of hose and water tender. In arid country road work the cost has to the writer's knowledge reached 50 ct. per cubic yard. To guess at the amount of a cost item of such possible magnitude and of such wide variation is not good engineering or constructing practice.

RESULTS OF SOME TESTS OF DOUGLAS FIR BRIDGE STRINGERS TO DETERMINE EFFECT OF CREOSOTE TREATMENT ON PHYSICAL PROPERTIES.

The following data refer to a series of tests made under the direction of H. B. MacFarland, engineer tests, Atchison, Topeka & Santa Fe Railway System, to determine whether moisture could be properly removed from Douglas fir bridge stringers by a process of creosoting involving boiling under vacuum, and to determine whether this method of treatment had a detrimental effect upon the physical properties of the material. The tests were reported in the Bulletin of the American Railway Engineering Association, Vol. 17, No. 184, from which we have abstracted the following:

Arrangement for Tests.—Arrangements were made with the St. Helens Creosoting Co. to treat a test lot of 100,000 ft. of 7 x 16-in. x 30-ft. commercial bridge stringers by the process of removing the moisture by boiling under vacuum, at a temperature of from 180° to 190° F. Selection of the material for treatment and for physical tests was made under the personal supervision of officials of the railway company and the consulting engineer for the Pacific Coast creosoting and timber interests. The work at the treating plant was conducted from Nov. 1 to 10, 1915, actual treating taking place from Nov. 4 to 8, 1915. The regular plant equipment was used, care being taken to check all gages and thermometers by calibrated instruments.

Material.—From a lot of 356 stringers in this order 61 were selected for test purposes. Fifty-two of these stringers were cut in two, the two halves being given corresponding test numbers, one-half being treated and the other half held as a control, to determine the effect of the treatment on the wood. Nine stringers were selected after treatment for special tests. All specimens selected for test were representative of the entire lot, as to physical structure and prevailing defects.

Treatment.—In the boiling under vacuum process of creosoting as practiced by the St. Helens Creosoting Co. the charge of green or watersoaked timber is placed in the retort, which is then filled with creosote oil at a temperature of from 150° to 180° F. The temperature of the oil is gradually increased to 190 F., and then held at that temperature, under atmospheric pressure, until the timber is uniformly heated. A vacuum is then drawn and the temperature maintained at 190° F. to remove moisture. In treating this material the preliminary heating period was 5 hours after the charge had attained the desired temperature. The boiling under vacuum was continued until the average condensation for two consecutive hours was less than 0.1 lb. of water per cubic foot of timber per hour; this required from 14 to 15½ hours, at the end of which period additional oil was added and a 5 to 10-lb. pressure applied to insure the retort being full of oil before the pressure pumps were started.

The steam in the heating coils was then turned off, and oil pumped from the measuring tanks into the retort. The pumping was continued and the pressure in the retort was increased until the desired treatment of 12 lb. per cubic foot was forced into the timber. This operation required from 4½ to 6 hours, and the pressure reached a maximum of 132 lb. per square inch. The oil was then forced back into the high tank with air pressure, and a vacuum drawn on the retort for 30 minutes to surface dry the charge.

Program of Tests.—To establish the effect of the treatment and to make allowance for changes in moisture content during the lapse of time between treatment at St. Helens and tests at Topeka, proper records of weights and moisture content of all specimens were taken at St. Helens and again at Topeka. The test material was shipped to the Topeka laboratory via boat and rail, arriving Dec. 20, 1915. On arrival it was piled outdoors until tested. Complete laboratory tests were made to determine the strength of the material. Tests on this material were started Jan. 17, 1916. These tests were as follows:

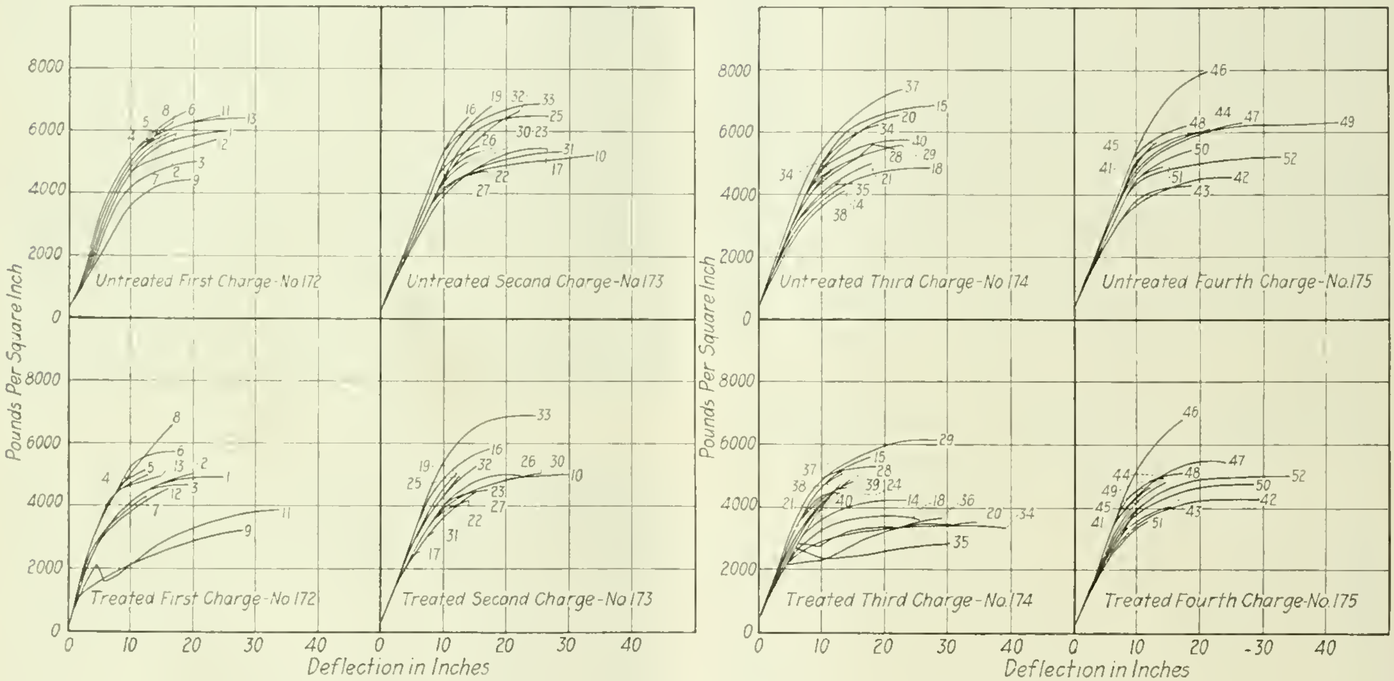
Test Data and Methods.

Transverse Tests.—Full size specimens 7 x 16-in. x 15-ft. were tested. Specimens were supported on two I-beams, placed on the table of a 200,000-lb. Olsen testing machine. A span of 14 ft. was used with the specimen mounted on rocking knife edges to allow movement on the I-beams. The load was applied at third points through knife edges. Steel plates 6 in. wide were used between the knife edges and the specimen to prevent damage to the wood fiber during application of the load. Rollers were used between the top knife edges and the plate to allow movement in a horizontal plane. Deflections were measured for the 14-ft. span by means of a fine steel wire and scale graduated to hundredths inch. The wire was stretched over two nails driven on the neutral axis vertically above the knife edge supports. It was placed so that it did not touch the face of the beam and was kept taut by means of a weight attached to one end. Deflections were read on a mirror scale fixed back of the wire on the neutral axis of the beam at the center. The speed of the machine was regulated to conform as nearly as possible to recommended practice as outlined in the government's instructions to engineers of timber tests.

On this basis the rate of load application was maintained to give a fiber strain at the rate of 0.0010 in. per inch of outer fiber length per minute. Deflection readings were taken while the machine was in motion.

Prior to transverse tests the specimens were weighed and a sketch made showing the exact dimensions, location of knots, shakes, checks, pith center, etc., as well as notes relative to structure and general characteristics of the individual specimen. The edge of the stringer on which the load would ordinarily be applied in bridge construction had been marked in selecting the stringers for test, and care was taken to conform to this position when placing both treated and untreated specimens in the testing machine. After placing each specimen in position, an initial load of 2,000 lb. was applied to give a firm bearing on the supports and the deflection scale then set at zero. The load was then uniformly applied and measured at increments of 5,000 lb. The weighing beam of the machine was kept floating after the elastic limit had been passed to record the maximum load. A description and sketch of failure for each specimen was made at the time of test.

Compression Parallel to Grain.—Specimens, 5x5x12-in., were tested. These were cut from the full-size specimens after transverse tests, care being taken to select them from the sound material. The ends of the specimens were accurately finished parallel and perpendicular to the axis to prevent lateral distortion of the fiber during test. Each specimen was weighed, measured and sketched before it was placed in the machine. An initial load of 2,000 lb. was then applied and the deflectometer set at zero. The load was then applied at a uniform rate and deflectometer readings taken at increments of 5,000 lb. to the elastic limit, the deflections being read while the machine was in motion. The machine was operated at a speed to produce a fiber strain of 0.0036 in. per inch of length per minute. The weighing beam of the machine was kept balanced after the elastic limit had been passed and until the maximum load was reached. A description and sketch of the specimen showing general characteristics and location of the failure were recorded on the log sheet.



Note:-Stringers 7"x16"x15'-0" supports 14' apart: loading applied as two concentrated loads at third points.

Fig. 1—Composite Curves Showing Results of Transverse Tests of Treated and Untreated Douglas Fir Stringers. Curves Show Variation in Individual Specimens and Effect of Creosote Treatment on Strength.

Compression Perpendicular to Grain.—Specimens, 6x6x30-in., were tested. These specimens were also cut from material used in transverse tests. In order to get comparable data the load was applied through a plate 6 in. wide, on the convex side of the growth rings. The specimens were weighed, measured, and sketched, and all defects described before being placed in the machine. An initial load of 500 lb. was applied and the deflectometers set at zero. The load was then applied in increments of 2,500 lb. to the elastic limit, the machine being stopped at each load increment to take the deflectometer readings. After passing the elastic limit only loads corresponding to deflections of one-tenth, three-sixteenths, and three-eighths inch were recorded. The average of the two deflectometer readings was taken as the true deflection. A description of the failure for each specimen was noted on the sketch made on the log sheet.

Moisture.—Both the amount and distribution of moisture in the timber were obtained from borings from the end of a newly sawed section. Seven 1-in. holes, 2 in. deep, were bored in the specimen. Borings from the four holes near the surface were kept separate from the three near the center in these determinations. A section 1 in. thick was also cut from each of the test stringers and dried to give the average moisture through the timber.

The percentage of moisture in all determinations was computed on a dry basis, i. e., weight of the dry wood was considered 100 per cent.

Absorption of Creosote.—The weight of creosote per cubic foot for the treated specimens was determined as follows:

The weight per cubic foot of dry wood in each treated specimen was assumed as being that of the corresponding untreated specimen from the same stringer. The actual weight for each untreated specimen was obtained and using the dry weight of the untreated specimen as above outlined and making moisture correction in the treated specimen, the weight of creosote absorbed per unit of volume was determined by difference. The creosote per square foot of area for each stringer was also computed from these data.

The maximum, minimum and average penetration of creosote were obtained from a newly sawed section 48 in. from the end of the specimen.

Formulas Used.—The following formulas were used in computing the strength of specimens in the transverse and compression tests:

For transverse test:

$$S = \frac{P}{A}; \qquad E.\,L. = \frac{P'}{A}; \qquad J = \frac{0.75 \times P}{b \times d};$$

$$R = \frac{L \times (P + 0.75 \times W)}{b \times d^2}; \qquad E = \frac{P' \times L^3}{4.7 \times b \times d^3 \times D}.$$

For compression test parallel to grain:

$$J = C.\,S. = \frac{P}{A}; \qquad E.\,L. = \frac{P'}{A}; \qquad E = \frac{P' \times d}{A \times D}.$$

For compression test perpendicular to grain:

$$C = \frac{P}{A}; \qquad E.\,L. = \frac{P'}{A}.$$

P = maximum load, pounds.
S = stress, pounds per square inch.
C = crushing stress at 0.5-in. compression, pounds per square inch.
C. S. = crushing stress, pounds per square inch.
J = shearing stress, pounds per square inch.

P′ = load at elastic limit, pounds.
E. L. = stress at elastic limit, pounds per square inch.
E = modulus of elasticity, pounds per square inch.
R = modulus of rupture, pounds per square inch.
W = weight of specimen, pounds.
A = cross sectional area, square inches.
L = length of span, inches.
D = deflection or compression at elastic limit, inches.
d = depth or vertical length of specimen, inches.
b = breadth of specimen, inches.

Graphs and Data.—Composite graphs showing the results of the transverse test for each of the four charges, superimposed to facilitate a study of the effect of treatment and variation in individual specimens are shown in Fig. 1. (Graphs for each individual specimen, showing the results of transverse and compression tests, were also given, but these have been omitted in our abstract. Complete data were also given covering the results of each test, together with the phenomena observed in the transverse test of both treated and untreated specimens.)

Discussion of Results.

Physical Structure.—Inasmuch as the material had been treated less than two months before the physical tests were made it was almost entirely free from season checks. The material passed the requirements for service as bridge stringers and was, therefore, free from injurious defects, such as large, loose knots, bad checks, shakes, etc.

The stringers were sawed from the heartwood of the log and contained very little sap wood. The lot tested contained 33 per cent box heart, and 67 per cent side cuts, as compared with 36 per cent box hearts and 64 per cent side cuts in the entire lot treated.

Treatment.—It is generally conceded that green or watersoaked timber cannot be satisfactorily treated until the moisture has been removed below a certain point in order to get the material in a receptive condition for creosoting. In creosoting processes, where temperatures of 240° to 350° F. are used in removing the moisture, the fiber is weakened, due to the high temperature. When boiling under vacuum at a much lower temperature, of only 180° to 190° F., less injury, if any, may be expected.

How much moisture is removed and how much oil can be pressed into the fiber is shown by the following summary of the plant inventory covering the treatment of the lot:

Charge No.	Plant No.	Retort.	Cu. ft. timber treated.	Total moisture removed, pounds.	Total oil used.	Oil, pounds required.*
1	172	E	2,448	10,760	30,400	29,350
2	173	F	2,154	7,040	23,450	25,650
3	174	F	1,695	7,140	22,850	20,300
4	175	E	1,675	6,840	23,000	20,100
Total			7,972	31,780	99,700	95,400

*To give treatment of 12 lb. of creosote per cubic foot.

These data show the removal of 4 lb. of moisture and a treatment of 12.5 lb. of creosote per cubic foot of timber.

The condition of the timber as to moisture and creosote before and after treatment, in pounds per cubic foot, is shown by the following table:

Charge No.	Plant No.	Retort.	Moisture: Before treatment.	Moisture: After treatment.	Moisture: Moisture removed.	Moisture and creosote.	Creosote.
1	172	E	10.3	6.6	3.7	19.9	13.3
2	173	F	10.7	7.0	3.7	18.2	11.2
3	174	F	10.3	7.4	2.9	18.1	10.7
4	175	E	10.8	7.0	3.8	17.3	10.3

The moisture content in the treated specimens was slightly greater at the time of test than just after treatment, as shown by difference in weights at St. Helens and at Topeka.

The removal of moisture, either by air drying or by artificial drying, constitutes the seasoning of timber. Former laboratory tests have shown a slight increase in the physical strength of treated Douglas Fir, due to seasoning.

Effect of Treatment.—The transverse tests show that the effect of treatment on the strength of Douglas fir stringers is as follows:

	Pounds per square inch: Maximum.	Pounds per square inch: Minimum.	Pounds per square inch: General average.	Per cent.
Elastic limit:				
Treated	5,280	1,136	3,481	82
Untreated	5,610	3,140	3,269	100
Modulus of rupture:				
Treated	6,690	3,020	4,680	82
Untreated	7,990	4,105	5,691	100
Modulus of elasticity:				
Treated	2,136,400	1,276,700	1,666,200	98
Untreated	2,153,800	1,204,400	1,701,900	100
Longitudinal shear:				
Treated	475	216	333	81
Untreated	565	299	411	100

These data show in the transverse tests that the elastic limit and modulus of rupture are decreased 18 per cent due to this treatment; the modulus of elasticity is decreased only 2 per cent, and the shearing strength is decreased 19 per cent.

A general classification of number of failures in transverse tests for treated and untreated specimens follows:

	Longitudinal shear. No. of failures.	Longitudinal shear. Per cent of total.	Tension. No. of failures.	Tension. Per cent of total.	Miscellaneous. No. of failures.	Miscellaneous. Per cent of total.
Treated	32	62	14	27	6	11
Untreated	16	31	29	56	7	13

From this table it is seen that for the treated specimens a majority failed by longitudinal shear, while of the untreated specimens, the majority failed by tension.

Treated specimens 9, 17, 34 and 35 showed peculiar shear failures along the line of pith center as shown by the graphs. These specimens showed an early failure by shear and later failed by tension, under a higher load. In all other shear failures the shearing took place at the maximum load.

The predominate type of shear failure was through the pith center in the box heart cuts, and near the line of pith center in the side cuts. From a total of 48 shear failures in the treated and untreated stringers, 33 specimens, or 69 per cent, were directly along the line of pith center.

Specimen 16, untreated, side cut, failed by shearing entirely along the growth rings, 5 in. from the pith center. Specimens 6 and 37, untreated, and 5 and 31, treated, failed by shearing along the growth rings for a short distance, and then across the grain.

The compression tests parallel to the grain show that the effect of treatment on the strength of Douglas fir is as follows:

	Pounds per square inch: Maximum.	Pounds per square inch: Minimum.	Pounds per square inch: General average.	Per cent.
Elastic limit:				
Treated	5,080	2,358	3,629	94
Untreated	5,173	2,611	3,873	100
Maximum load:				
Treated	5,235	2,590	3,869	94
Untreated	5,530	2,750	4,114	100
Modulus of elasticity.				
Treated	814,500	409,500	607,110	101
Untreated	811,000	413,000	601,020	100

This table shows that in compression, the strength of this material is decreased 6 per cent at the elastic limit and 6 per cent at the maximum load, due to treatment. The modulus of elasticity shows the treated material 1 per cent stiffer than the untreated material. The specimens for this test were sawed from the material after transverse test, and had a part of the area of the treated specimens penetrated by creosote.

The compression tests perpendicular to the grain show that the effect of treatment on the strength of Douglas fir is as follows:

	Pounds per square inch: Maximum.	Pounds per square inch: Minimum.	Pounds per square inch: General average.	Per cent.
Elastic limit:				
Treated	615	206	322	74
Untreated	627	346	438	100
Load for deflection of 3/8-inch:				
Treated	900	450	640	82
Untreated	1,100	590	780	100

This table shows that the strength of this material in compression was decreased due to treatment by 26 per cent at the elastic limit and by 18 per cent at a load which caused 3/8-in. deflection.

Special Test.—A special test was made to determine the effect of the area penetrated by creosote on the physical strength of treated stringers, as compared with the area not penetrated.

Treated stringers 53 and 55, each 30 ft. long, were cut in 15-ft. lengths. One-half of each stringer was numbered 53 and 55 and the other half of each stringer 53-A and 55-A, respectively. Specimens 53-A and 55-A were planed on the sides and edges, so as to remove the area penetrated by the creosote, prior to transverse tests. The results of transverse test were as follows:

					Weight per cu. ft.	
Specimen.	Sectional area, sq. in.	Elastic limit, lb. per sq. in.	Modulus of rupture, lb. sq. in	Modulus of elasticity, lb. per sq. in.	Actual.	Creosoted area planed off
53	111.7	3,860	4,760	1,389,800	44.0	....
53A	70.0	3,820	5,400	1,705,000	36.0	57.4
55	112.0	3,270	3,790	1,214,100	38.1	....
55A	70.0	2,860	3,505	1,531,900	31.0	50.3

The above table shows a slight increase in the modulus of rupture for specimen 53-A over specimen 53, while it shows a slight decrease in elastic limit and modulus of rupture for specimen 55-A over specimen 55. The average of the above data shows that the modulus of elasticity is the only property which is appreciably increased by removing the creosoted portion.

The weight per cubic foot of the area actually penetrated by creosote in the above specimens is approximately twice the weight of dry wood.

Penetration of Creosote.—A table showing the absorption of creosote and the area of penetration is as follows:

	Creosote, pounds			
	Per cu. ft.	Per sq. ft. of exposed area.	Average depth of penetration, inches.	Per cent of area penetrated by creosote.
Average	11.4	2.27	....	20.4
Maximum ...	17.2	3.42	0.89	34.6
Minimum ...	3.5	0.70	0.20	12.0

The maximum value in the above table is for specimen 6 and the minimum value for specimen 35. Specimen 6 had a large percentage of summer wood and was of a very compact structure; and specimen 35 had a large percentage of spring wood. The summer wood in this specimen was of a spongy, open structure. A study of the structure and the creosote per cubic foot shows that the structure having a large percentage of summer wood has a high value for creosote per cubic foot, and that the structure having a high percentage of spring wood has a low value for creosote per cubic foot. This is due to the fact that the soft, spongy fiber of the spring wood offers greater resistance to the penetration of creosote than the structure of the summer wood. Specimens 14, 18 and 27, which have 21 or more growth rings per inch, show values for creosote per cubic foot which are below the average value.

Conclusions.

The results of these tests indicate the following conclusions relative to the boiling under vacuum process of creosoting Douglas fir bridge stringers:

1. The moisture may be successfully removed by boiling under vacuum for the proper treatment of the material. Moisture determinations show that on an average 35 per cent of the total moisture was removed by this process.

2. The removal of moisture by the boiling under vacuum process, preliminary to creosoting, decreases the physical strength of the material.

3. The weight of creosote per unit of volume for treated material is dependent on the structure of the specimen. The spring wood offers greater resistance to treatment than the summer wood.

4. Special test of treated stringers 53 and 55 indicate that the decrease in physical strength due to treatment is not confined to the area penetrated by creosote, but that the entire structure is affected.

6. The compressive strength parallel to the grain was decreased 6 per cent due to boiling under vacuum process.

7. The compressive strength perpendicular to the grain was decreased 26 per cent due to the boiling under vacuum process.

8. Although the average strength of the treated material is appreciably decreased, its stiffness, as measured by the modulus of elasticity, is not affected.

9. In general, the average strength of Douglas fir bridge stringers, subjected to the boiling under vacuum process of creosoting, was five-sixths of its original strength.

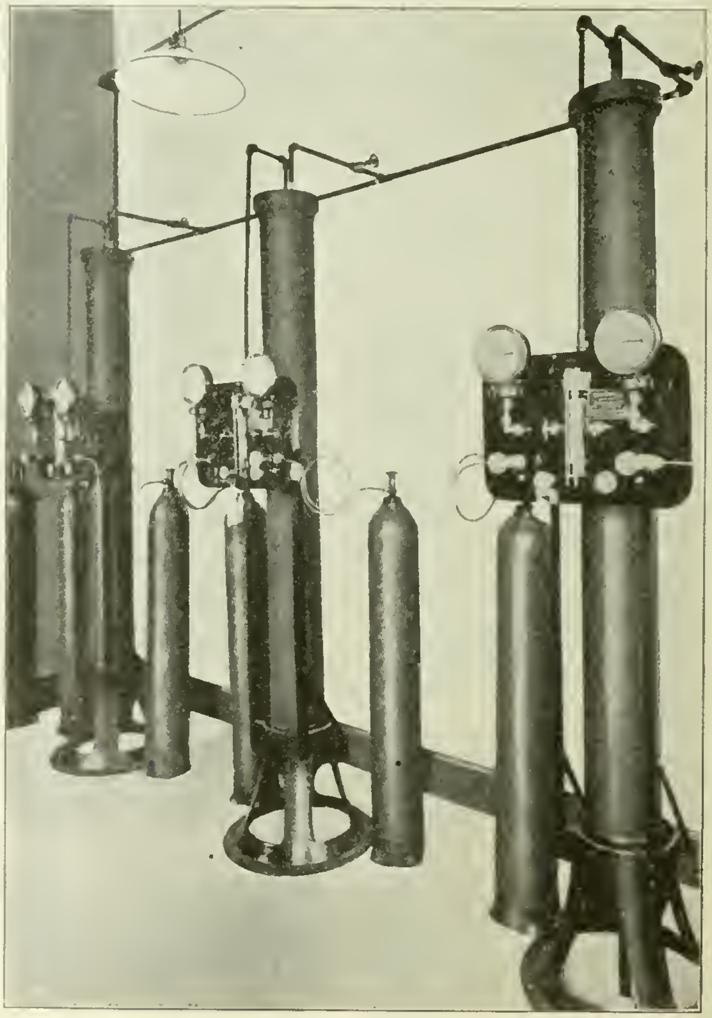
EXPERIENCE IN THE CHLORINATION OF MILWAUKEE'S WATER SUPPLY.*

By H. P. Bohmann, Superintendent of Water Works, Milwaukee, Wis.

The very remarkable development of liquid chlorine as a means of water purification in the destruction of germ life in water, has induced a number of large as well as smaller cities to change to this method of water purification.

After carefully investigating the relative merits of liquid chlorine and hypochlorite of lime, the superior advantages of liquid chlorine seemed so apparent, both from the standpoint of greater efficiency as well as economy, that this method of treatment was adopted and placed in operation on March 31, 1915.

The accompanying illustration shows the apparatus which was installed at the North Point Pumping Station by the Electro Bleaching Gas Co., of New York City. There are three units each capable of treating from 20,000,000 to 50,000,000 gal. of water in 24 hours. The equipment is installed in a room isolated from the rest of the pumping station. The chlorinated water solution is conveyed by means of hard rubber tubing from the apparatus to the short shaft of the intake tunnel, a distance of about 90 ft. The vertical section reaching down the short shaft, consisting of steam hose, is 50 ft. in length. The application of the solution at this point assures a complete mixture, as it is approximately 200 ft. from the pumping engines.



Battery of Chlorinators Installed in North Point Pumping Station, Milwaukee Water Works.

While the efficiency of liquid chlorine has been higher than that of hypochlorite of lime, the results accomplished in other cities where liquid chlorine is used, have not been obtained here. In some cities it was found that 1 lb. of liquid chlorine was equal in sterilizing value to from 8 to 10 lb. of hypochlorite of lime. Based on our results in the use of hypochlorite of lime it was confidently expected that we would be able to sterilize our water supply with not to exceed 1 lb. of liquid chlorine per 1,000,000 gal. of water. Our experience, however, has been that in order to get satisfactory results we were obliged to use from 32 to 36 ounces per 1,000,000 gal. of water which is equivalent to 0.24 to 0.27 parts available chlorine per million parts of water treated and gives us a ratio of 1 lb. of liquid chlorine to about 3 lb. of hydrochlorite of lime.

---

*From 1915 annual report.

The difficulty of treating a water having but little organic matter especially when the temperature of the water in the lake drops to as low as 33° F. became apparent during the latter part of the year. Daily tests made by our chemist showed free chlorine present in nearly every sample of water taken. As this is objectionable and produces both taste and odor, it may become necessary to use some neutralizing agent such as lime water or sodium thiosulphate to take up any free chlorine present in our treated water, as we cannot reduce the amount of liquid chlorine applied without decreasing the efficiency of the treatment.

The typhoid death rate of 4½ per 1,000,000 of population is again lower than that of the preceding year, and is the lowest in the history of the city.

SOME DESIGN AND CONSTRUCTION FEATURES OF THE SECOND INFANTRY ARMORY, CHICAGO, ILL.

The Second Infantry Armory, which is nearing completion in Chicago, has a frontage of 236 ft. on Madison St. and extends through to Monroe St., a distance of 266 ft.

Design Features.—An alley leads through the center of the block parallel with Madison St., and for the privilege of building across this alley it was necessary to provide alleys on both sides of the building extending from the center of the block to Monroe St. This resulted in a T-shaped structure, the Madison St. frontage of which has a height of three stories and basement, with a large central tower five stories high; while the rear portion consists of the arched drill hall, 200 ft. wide, 126 ft. long, and 90 ft. high. The roof and balcony of the drill hall are supported by three-hinged steel arches. These arches have a span, center to center of end pins, of 198 ft. and a height of 89 ft.; they are spaced 37 ft. on centers, and are connected by deep latticed struts, which in turn support the curved roof purlins. The armory is of fireproof construction throughout, with reinforced concrete foundation, basement walls, and floors. A balcony extends around three sides of the drill hall. The lower half of the first story is faced with blue Bedford stone, above which there is a facing of red velour brick with Bedford stone trim.

The basement contains 28 shower baths, general toilets, wardrobe accommodations for 7,000 people, boiler and fan rooms, a wagon storage connecting with the alley by a wide incline, and a range for rifle and pistol practice. On the first floor there are two field-gun company rooms, quarters for hospital corps, band, quartermaster and janitor, and twelve company rooms facing the drill hall. The second floor contains quarters for the medical examiner, surgeon, ordinance and petty officers, and commissioned officers. On the third floor there is a gymnasium 63x82 ft., a banquet hall with a stage 63x82 ft. x 22 ft. high, toilet rooms, showers, a smoking room, and a kitchen. The fourth floor contains two signal corps rooms, while the fifth floor is divided into storage and fan rooms.

Construction Features.—The construction features of greatest interest include the methods used in erecting the large arched frame of the drill hall, and the placing of concrete over the large building area.

The arches were assembled on the ground and then riveted up into two complete segments, each about 120 ft. long. They were erected by a steel traveler, 38 ft. square and 38 ft. high, on which were mounted two 90-ft. booms. The heels of the segments were first lifted into place on their cast supporting shoes, and the heel pins driven. The tackle of each boom was then attached to a segment at a point near the crown pin, and the two segments raised simultaneously, pivoting on the heel pins, until the crown-pin holes registered, when the crown pin was driven. By this procedure the booms were required to lift only about one-fourth of the weight of an arch, the total weight of which was about 36 tons.

The concrete required for this building was mixed in two ⅓-cu. yd. "The Standard" low-charging mixers. Concrete materials were delivered by motor trucks to points near where they were to be used, and the mixers moved along as the work progressed. This procedure permitted a considerable quantity of the concrete to be spouted directly from the mixers into the forms. In other cases, where carts were used, it was necessary to wheel the concrete only short distances. The portability of the mixers also enabled them to be moved several times during construction by being picked up bodily by the travelers and carried to new positions. For placing concrete in the balcony a mixer was stationed near the center of the drill hall and a spouting tower erected. The spout was suspended from the steel frame of the drill hall, and the concrete was delivered by it to a bin on an elevated platform, from which it was gated into barrows for distribution. The portability of the mixers contributed largely to the efficient placing of the concrete on this work.

The armory was designed by James B. Dibelka, state architect of Illinois, and it is being constructed by the C. E. Carson Co., of Chicago.

METHOD OF BREAKING THROUGH A SUBMERGED TUNNEL HEADING.*

By R. E. Murphy, Juneau, Alaska.

On Feb. 14 the pillar of rock between the face of the Alaska Gastineau Mining Company's Annex Creek Tunnel and the waters of Annex Lake was shot away. The project was a complete success. Some months ago several diamond drill holes were driven from what was then the face of the tunnel through the rock into the lake. Thus at all times the distance from the tunnel heading to the water of the lake could be estimated. When the tunnel had been driven to within approximately 5 ft. of the water, a pocket was cut on each side of the tunnel for the full height. From each of these pockets two holes were driven toward the lake with the regular machine drills (Sullivan Water Machines), one of the holes being near the top and one near the bottom in each pocket. These holes were driven through into the lake and thus gave the approximate distance from the tunnel face to the water of the lake at each corner of the tunnel. In order to control the flow of water from these holes when the drill would break through into the lake, an extra large starting steel was used and a nipple was driven into the hole made by this steel and cemented into place, then a valve was fitted to this nipple. All the other drills used were of the ordinary size and were passed from the machine through the valve and to the rock beyond, and the remainder of the hole drilled in this manner. When the steel broke through into the lake, a mark was made on it where it entered the valve, the steel withdrawn from the hole, the valve closed and the water shut out. Then by measuring the distance between the mark made on the drill at the valve and the drill bit, the distance to the water was obtained.

This method was used on each of the four pilot holes and by ascertaining the distance between the tunnel face and the lake at these points a good idea of the profile of the rock on the side next to the lake was secured. Eighty-four holes were then drilled in the face with the regular machine drills. These holes were drilled to what was estimated to be 12 in. from the water. By this time the tunnel face was making a great deal of water, which was to be expected when it is taken into consideration that 84 holes had been drilled to within 12 in. of the water which at this point had a vertical height of 150 ft., thus exerting no small pressure. It also must not be overlooked that this same 12-in. shell of rock had been subjected to some hard hammering during the process of drilling these 84 holes. The holes were spaced about eight inches apart, nine of them were very wet and were not loaded. The other 75 were loaded with 750 lb. of 40 per cent Dupont gelatine. The dynamite was tamped into the holes to within 12 in. of the collar and then the remainder of the hole was tamped solidly with fire clay. This was expensive tamping, but very efficient and in fact the only clay available in the vicinity of Annex Lake with 20 ft. of snow on the ground. Dupont No. 6 Electric Blasting Caps were used to detonate the dynamite. There were no special water-proof Electric Caps in stock here, so the ordinary ones were waterproofed in the following manner: First caps, wire and all were dipped into a can of Celakap and allowed to dry. The cap and each wire were then wrapped with electrician's tape and painted over with a paraffin paint used by electricians in making waterproof joints. All the wires of the caps had been cut off so as to leave just sufficient wire to make the connection. All connections were taped and waterproofed. Each cap was tested with a Du Pont Galvanometer before being taken into the tunnel and the circuit was again tested after the connections had been made. The wires strung from the roof and used for the lighting system during the driving of the tunnel were repaired and tested and these were used for lead wires. The tunnel made a turn about 50 ft. back from the heading and a bulkhead of fine muck from the face was built up here entirely blocking the tunnel, and a similar bulkhead about 300 ft. nearer to the portal. After all connections were made and tested, the bulkheads built, etc., the outlet valves at the portal were closed and water turned into the tunnel from the outside. The tunnel was driven on a one per cent grade and was approximately 1,400 ft. long. As the tunnel was 7 ft. high, when the water was up to the roof at the portal it was only level with the bottom 700 ft. back in the tunnel. The tunnel was allowed to fill until the meter showed that sufficient water had entered to fill the tunnel to the bulkhead nearest the portal. A pressure gage was then connected with the water in the tunnel and the shot was fired with a Du Pont No. 5 Blasting Machine. At the minute of explosion the pressure gage only registered an added pressure of 10 lb., but the concussion was strong enough to shake the snow off the trees several hundred feet away. The head gates were then opened and the water allowed to run through the waste gate until the tunnel had cleared itself, when the water was turned into the pipe line and proceeded to generate electric power at the beach a couple of miles away.

---

*Extract from Du Pont Magazine for May, 1916.

This is the first time that a project of this kind has been attempted with the tunnel cemented and the head gates in place at the time of firing the final blast to tap the body of water. The work was under the personal direction of Mr. H. L. Wollenberg, Chief Engineer of the Alaska Gastineau Mining Co., and his assistant, Mr. J. A. Wilcox.

FILING AND INDEXING DRAWINGS, ENGINEER DEPARTMENT, DISTRICT OF COLUMBIA.

A new method of filing and indexing drawings was devised and put into operation, last year, in the Water Department of the Engineer Department of the District of Columbia. These drawings are filed in rooms 310 and 312 of the District Bldg., and these room numbers are here retained as reference numbers. Our information is from the latest report of D. W. Holton, Assistant Engineer, Water Department, to J. S. Garland, Superintendent Water Department.

Old System.—In room 310 the drawings, under the old system, were filed flat in 9 drawers 27x39x2½ in. deep. The numbering of the drawings was begun with 100; 100 to 199 being in the first drawer, 200 to 299 in second, etc., each 10 numbers being divided by sheets of heavy cardboard. The drawings as made were numbered in consecutive order and filed away and in some cases indexed only under the first letter of the title, and unless one could correctly guess the title, a lot of time was wasted trying to find the drawing. If one wished to get all the drawings of one machine or apparatus together, if they had been made at various times, it was necessary to search through the index to find the various numbers, instead of finding the information on one card.

About the time that the 800 drawer was put into use we began to use sheet and subnumbers for related drawings made up at the one time, instead of using a separate consecutive number for each drawing. By the time 899 was reached this drawer contained 365 drawings and prints and, as the heavy cardboard sheets took up half the depth, the drawer was overcrowded, heavy, and hard to handle, while the other drawers were not much over half filled—in some cases where drawings had been lost—containing less than 100 drawings, quite a number of which were obsolete. This system lacked flexibility and the time was fast approaching when the capacity of the nine drawers would be reached. By overcrowding drawer No. 9 as badly as No. 8, about 200 more drawings could have been filed, making a total of about 1,300.

New System.—It is estimated that by the new system at least 5,000 drawings can be filed in these drawers.

In the new system the heavy cardboard is replaced by detail paper, twice as long as the drawer is deep, which, when folded in the middle, forms a pocket, of which there are 10 to the drawer. These are cut so as to show tabs on the outer ends one-tenth the width of the drawer. On these tabs are marked the drawer letter, the index number of the pocket, and the kind of drawings contained in the pocket. On the outside of each drawer is a card bearing the drawer letter and description of the kind of drawings it contains.

Theoretically, each pocket will contain 100 drawings, and each drawer 1,000, but it is estimated that each drawer will actually contain about 600 drawings, and all the drawings of the same kind are in the one pocket, and we have found that in most cases it is possible to get out the desired drawing or drawings without resorting to the use of the index.

In the old system we used an alphabetical and a numerical index. In this system we also use two indexes—the first, an alphabetical, in which each machine, appliance, or apparatus is given a card; the second is a drawer index, divided into sections by tab cards bearing the index letters of the drawers. These sections being subdivided by tab cards bearing the pocket numbers from 1 to 9. These divisions contain a separate card for each drawing or set of drawings, and by consulting this index it is easy to find the next number required for a new drawing.

The use of this system has resulted in the saving of a great deal of the time formerly expended by the old system in getting out drawings when they are required.

Putting this system into operation required the making and lettering of 90 pockets, two new indices, and the renumbering of all the drawings.

In room 312 the miscellaneous maps, plats, profiles, etc., are filed in rolls, in a cabinet containing 100 compartments 4x4x42 in. deep. The maps, etc., vary in width from 10 to 42 in., and in taking out and replacing the drawings they would become disarranged, the smaller ones frequently being pushed back out of sight, and when they were required, a good deal of time was lost in recovering them. To correct this, the drawings were divided into three sizes: First, up to 18 in. long; second, up to 24 in. long, and third, those over 24 in. long. Fillers were made for 60 of the compartments by using two pieces of ⅞-in. poplar 4x4 in. separated by a strip of ⅞-in. board, placed diagonally, to which they were nailed. Thirty of these were made 18 in. long and 30, 24. long, and they have effectively solved the problem. This arrangement made necessary the renumbering and indexing of these drawings. In doing this all charts, diagrams, and drawings of a miscellaneous character were transferred to the filing cabinet in room 310, which already contained drawings of this character, while the maps found in the filing cabinet in room 310 were transferred to room 312, thus making it unnecessary to search through the indexes in both rooms in order to find a drawing.

METHODS AND EQUIPMENT USED IN CONSTRUCTING THE METHODIST BOOK CONCERN BUILDING, CINCINNATI, O.

The American Book Concern Building, Cincinnati, O., is a six-story reinforced concrete structure with basement and sub-basement. The building, which is 120x190 ft., was constructed in two sections, the western section, facing on Plum St., being constructed first without interfering with the old building, which was located at the rear of the lot. When the first section was completed the plant of the company was moved into this section, after which the old building was wrecked and the east half constructed.

As the east half of the building faces on a narrow alley the space available for storage was very limited. A quantity of sand and gravel suitable for use in concrete was obtained from the excavation, and a plant was therefore erected for handling a portion of these materials direct from the basement. On account of the congested condition at the site the remainder of the sand and gravel had to be hauled away and stored on a nearby lot and brought back after the plant was installed.

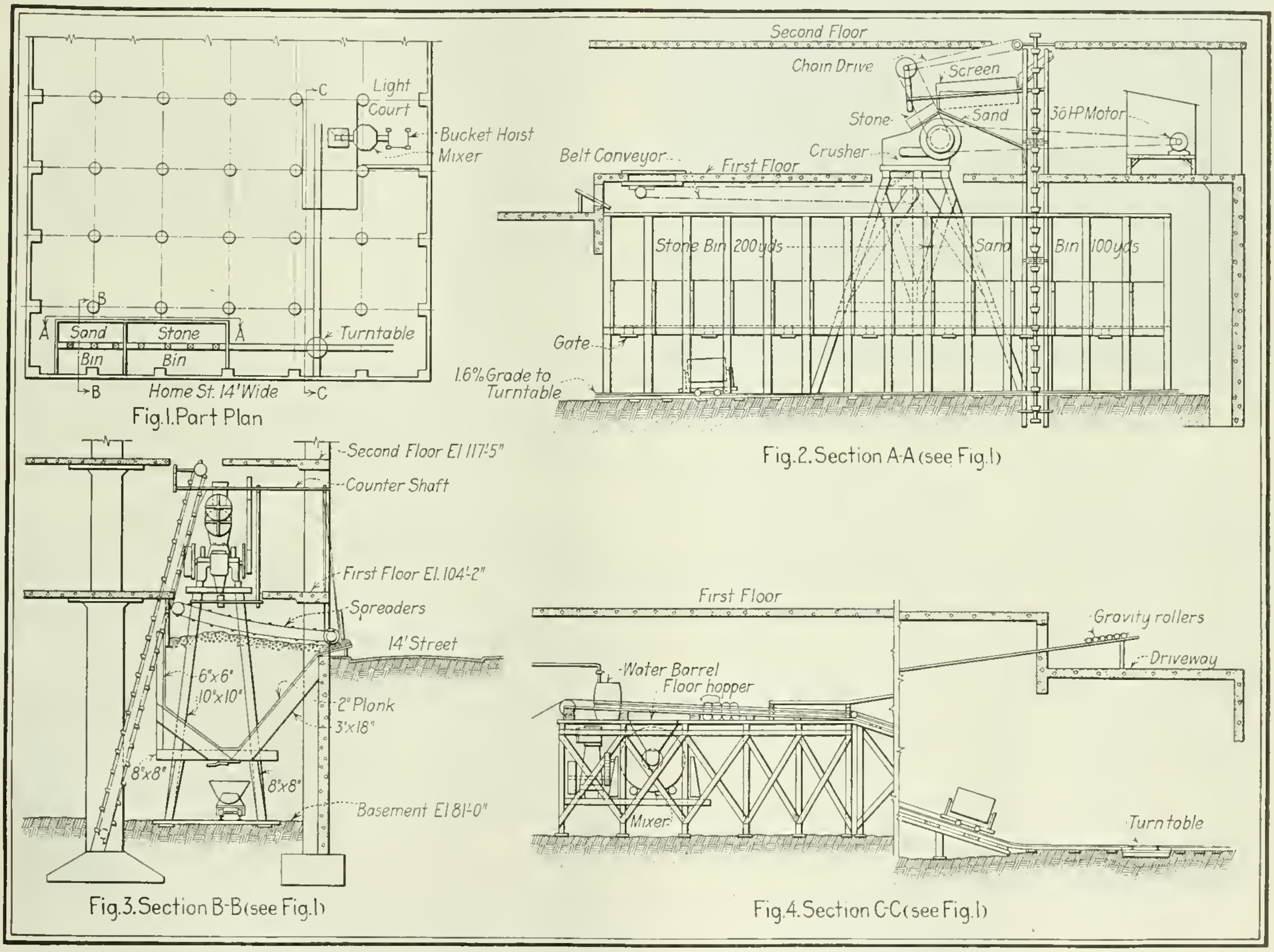


Fig. 1—Part Plan of Methodist Book Concern Building, Cincinnati, O., Showing Location of Storage Bins and Mixing Plant. Fig. 2—Elevation of Sand and Stone Bins and of Crusher and Screening Plant. Fig. 3—Cross Section of Material Bin Showing Relative Positions of Machinery and Street. Fig. 4—Elevation of Mixing Plant and Feeders for Same.

Storage Bins and Equipment.—The general arrangement of the mixing plant is shown in Fig. 1, and an elevation of the sand and stone bins in Fig. 2. The gravel was hoisted from the basement in the bucket elevator shown in Fig. 2 and dumped into a revolving sand screen which was supported above the first floor, holes being left in the first and second floors for this purpose. The sand passed through the screen directly to the sand bin, while the gravel passed to the stone crusher, from which it was carried on a belt conveyor to that portion of the bin where it was desired to dump the crushed stone. The dumping of the stone was accomplished automatically by tilting the belt, this being done by placing a stick between the belts, which tipped the upper one. The plant was operated by a 35-hp. motor located on the first floor (see Fig. 2).

A cross section of the sand bin is shown in Fig. 3. This drawing indicates the manner of handling the portion of the material brought to the job in end-dump wagons. The sand and gravel were dumped directly into the projecting portion of the bin (see Fig. 3), and were pulled away by a spreading belt. Some large stones were delivered to the site, and these were unloaded on the first floor and placed in the crusher by hand.

As the headroom available was limited, a special hopper was designed for use at the outlets of the bins, three outlets being placed in the sand bin and four in the stone bin. This hopper gate projected only about 2 in. below the bins.

Mixing Plant.—The aggregates were drawn from the bins into a Koppel car, which was so divided that a third of the car was filled with sand and two-thirds with stone. This car was run by gravity down a slight grade to a turntable (see Fig. 1), from which is was drawn by cable up to the mixing platform (see Fig. 4) and dumped into the hopper. The cement was delivered to the mixing platform from a driveway which extended into the building a little below the first floor; it was unloaded in this driveway and was handled by gravity rollers to the mixing platform. The retaining walls of the building were concreted before this equipment was installed, but the first floor was concreted with this plant, the cement being handled by a set of rollers placed temporarily for this purpose. A gate was placed at the bottom of the hopper at the mixer, which permitted a charge to be held in the hopper at the same time that another was being mixed. Details of the mixing plant are shown in Fig. 4.

Hoisting and Distributing System.—After the concrete was mixed it was hoisted in a bucket hoist and dumped into a hopper fastened to a sliding frame on the tower, this frame being moved upward as the work progressed.

The first length of chute was held by a split boom, which was fastened to the sliding frame of the tower hopper (see Fig. 5). The second length of chute was fastened at its upper end to the first chute, and its lower end was supported by an A-frame mounted on three large wheels which could be moved readily over the floor reinforcement without displacing it (see Figs. 5 and 6). The third section of chute was fastened to the lower end of the second section, and its lower end was supported by a two-wheeled frame, which rolled over the floor reinforcement as in the case of the A-frame. A short section of chute, which was moved about by hand, was used to place the concrete in the extreme corners of the building.

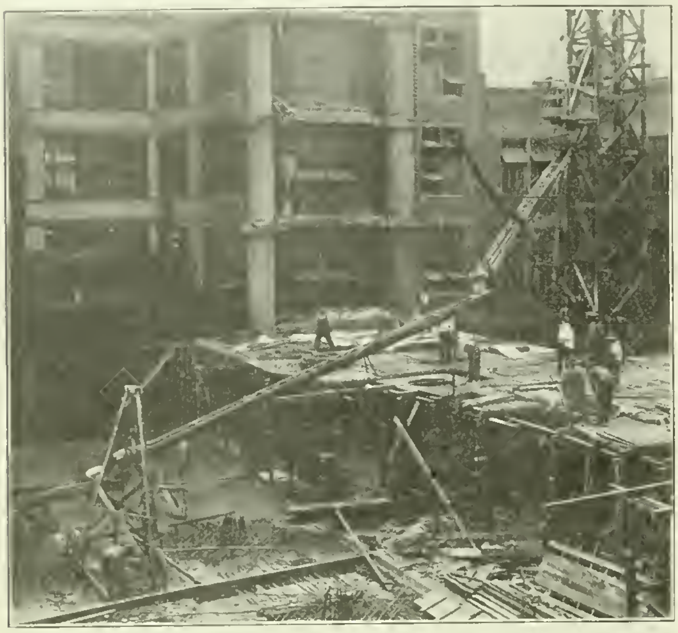


Fig. 5—View Showing Concrete Distributing System for Methodist Book Concern Building.—Note Split Boom and Three-Wheel Carriage.

Cost Data.—The plant described enabled the concrete work to be done with great rapidity, a floor containing 12,000 sq. ft. being completed every six working days.

The west section of the building, which was completed first, and on which the A-frame and two-wheeled frame were not used to shift the position of the chutes, contains 3,657 cu. yd. of concrete. Part of the work on this section was done in winter and required protection from the cold. The labor cost on this section was $1.46 per cubic yard. The east, or second section, contains 4,806 cu. yd. of concrete, the labor cost on this section being $1.29 per cubic yard. The floor area in this section was somewhat larger, and an improved distribution system was used in concreting it. In addition, no large boulders were encountered, and no winter work was necessary.

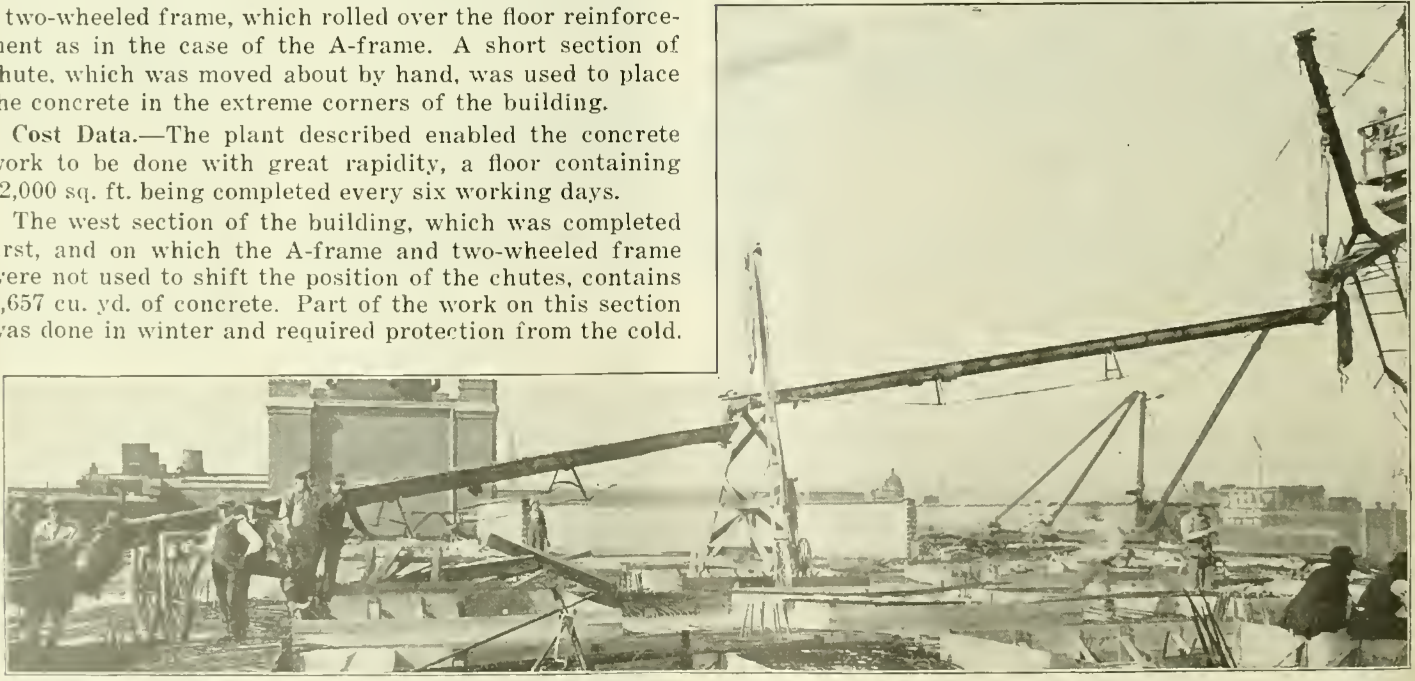


Fig. 6—View Showing Distributing System for Concreting Extreme Portions of Methodist Book Concern Building.—Note Split Boom, Three-Wheel Carriage, and Two-Wheel Support for End Sections of Chute.

The following table gives the itemized labor cost, per cubic yard of concrete, for each item of the work for both the east and west sections:

Item.	West (first) section.	East (second) section.
Labor on equipment	$0.256	$0.279
Unloading concrete materials	0.10	0.142
Mixing concrete	0.43	0.244
Hoisting and placing concrete	0.223	0.180
Cleaning up, patching, and caring for sacks	0.242	0.207
Idle time	0.027	0.031
Elevating material from cellar to bin	.....	0.156
Protection	0.096	.....
Removing gravel and boulders, including screening out material too large for concrete	0.087	.....
Labor, erecting bins	.....	0.053
Total labor cost	$1.161	$1.292

It will be noted that the costs given are for labor alone. To obtain total cost of the concrete an additional charge of about 30 ct. per cubic yard should be made, in addition to the cost of the aggregates and cement, this amount covering the cost of water, wearing out of small tools, etc. The lumber used in erecting the storage bins was obtained by wrecking the old buildings, the only additional cost being for bolts, nails, and necessary iron work.

Personnel.—The general contract for construction was executed by The Ferro Concrete Construction Co., Cincinnati, O. The architects for the building were Samuel Hannaford & Sons. The mixing and distributing plant was designed by J. E. Hodges, superintendent for the contractor. We are indebted to W. P. Anderson, president of The Ferro Concrete Construction Co., for the data on which this article is based.

New York Law of Interest to Contractors.—The New York legislature has passed and Gov. Whitman has signed a law permitting the corporation in which a city official is a director to accept a contract with the municipality. The fact that he is a director is not to be grounds for the inability of his corporation to accept such contract.

Experience with Water Meters at Iowa Falls, Ia.—The experience of Iowa Falls with water meters is proving most satisfactory and is of interest to other municipalities operating a water system, inasmuch as the economy in the use of water as well as the increase in revenues are most satisfactory. During the past year the increase in the income of the water department has been $1,668, besides saving on the other end in labor, fuel and other items of operation of the plant. The increase in the income of this department is sufficient to meet the city manager's salary.

METHODS AND COSTS OF CONCRETE ROAD MAINTENANCE IN OHIO.*

By A. H. Hinkle, Deputy Highway Commissioner, Ohio State Highway Department.

The maintenance work on the state roads of Ohio has been done under the direct supervision of many different patrolmen, foremen and superintendents. This is due to the fact that our state roads for the most part are disconnected short sections of road scattered far and wide over the entire state. Hence we cannot boast of getting the maximum efficiency out of our men until we have longer stretches of the same type of highway. Following are the methods used in repairing the various kinds of defects found in our concrete roads.

Method I—Cracks and Joints.—The defects in our concrete roads consist largely of cracks and joints, the edges of which have been spalled by traffic. These are swept clean with steel or rattan brooms and filled with hot tar passing the Department's specifications for Bituminous Material T-1,† which specifications read as follows:

Bituminous Material T-1 shall include only coal tar products which shall meet the following requirements:

(1) The tar shall have a specific gravity of not less than 1.200 nor greater than 1.270 at 25° C.

(2) On extraction with carbon disulphide, it shall not contain more than 22 per cent nor less than 10 per cent free carbon.

(3) Upon ignition it shall show not over 0.5 per cent inorganic residue.

(4) The consistency as determined by the Howard & Morse float apparatus at a temperature of 50° C. shall be not less than 2 minutes nor more than 3 minutes.

(5) When distilled by the method proposed by the American Society for Testing Materials, it shall yield no distillate at a lower temperature than 170° C., not more than 10 per cent by weight shall distill below 270° C., and not more than 20 per cent by weight shall distill below 300° C. The specific gravity of the entire distillate shall be not less than 1.03 at 25° C. The residue from the foregoing distillation shall have a melting point not greater than 75° C. by the cube method.

(6) The tar shall be free from water and shall not foam when heated to 300° F.

(7) All bituminous material used in a given construction shall be uniform in character, appearance and viscosity.

Where necessary, a thin piece of steel bent in the form of a hook (usually made by the local blacksmith) and attached to a wooden handle, is used to loosen and remove from the cracks any matted earth or other foreign material. The old tar in the cracks, after having been once filled, is not removed when refilling with tar. The newly poured tar is covered with sand or No. 6 (½ to 3/16-in.) grit or gravel, broken stone, or slag. While a coarse sand is preferable to a fine one, any sand suitable for concrete purposes has been used with satisfactory results. Superintendents are instructed to allow the tar to lap over the spalled edges of the crack or joint, but not more than 1 in. With the tar lapping over the edges but a small distance it is soon ironed out by the traffic, leaving a smooth, uniform surface.

---

*Extract from committee report to the Second National Conference on Concrete Road Building.

†This grade of tar corresponds very closely to Tarvia X of the Barrett Manufacturing Co.

TABLE I.—TAKEN FROM 1915 ANNUAL REPORT. CONCRETE ROADS REPAIRED BY OHIO STATE HIGHWAY DEPARTMENT.

Year built.	County.	Road No.	Section of road.	Pavement. Length, miles.	Pavement. Width, feet.	Amount expended from Nov. 16, 1914, to Dec. 31, 1915. Roadhed.	Surface.	Bridges and culverts.	Supt.	Total.
1915	Ashtabula	150	H	5.09	16	$ 93.33	....	....	....	$ 93.33
1912	Ashtabula	151	E	1.61	16	....	$215.92	....	....	215.92
1914	Coshocton	450	B	1.34	16 & 20	49.88	61.85	....	$119.93	*38.53 193.13
1913	Erie	3	E	1.00	12	20.75	....	....	....	20.75
1913	Erie	288	D	1.00	10	....	18.75	....	....	18.75
1913	Franklin	49	D-3 E-2	2.85	14	67.50	....	....	....	67.50
1913	Geauga	15	D & E	2.80	14	189.05	89.51	....	14.00	292.56
1915	Geauga	15	G	2.45	10	7.00	....	$ 1.25	....	8.25
1915	Guernsey	349	J	0.69	14	....	10.40	....	....	10.40
1914	Huron	290	G	2.60	14	1,840.14	150.00	....	142.15	2,132.29
1914	Huron	290	H	2.58	16	43.00	50.00	....	7.00	100.00
1913	Huron	290	N	1.25	10	1,673.00	100.00	....	127.00	1,900.00
1914	Huron	289	J	1.63	16	30.91	119.30	....	10.70	160.91
1914 & 1915	Licking	1	G	13.83	16	....	21.25	....	....	21.25
1913	Licking	47	F	3.92	16	....	125.06	....	....	125.06
1914 & 1915	Lorain	3	J	5.62	14	1,675.94	....	....	110.85	1,786.79
1914	Lorain	290	K	0.65	16	44.60	....	....	....	44.50
1914	Lorain	291	G	1.35	12	....	43.75	....	....	43.75
1913 & 1914	Meigs	395	H & I	3.19	12	1.336.59	114.27	....	290.24	1,741.10
1912	Mercer	211	A	1.60	14	220.88	17.78	....	41.97	280.63
1912 & 1913	Miami	245	A	6.00	16	4.60	105.46	....	75.50	185.56
1915	Monroe	7	F	1.08	14	4.25	....	....	....	4.25
1914 & 1915	Muskingum	1	I	10.12	16	....	457.13	....	59.16	516.29
1914	Muskingum	344	K	1.55	14	160.99	100.00	....	40.00	300.00
1912	Muskingum	344	E	1.07	16	22.74	257.78	....	55.80	336.32
1915	Muskingum	351	M	1.32	14	31.00	26.01	....	11.25	68.26
1912 & 1913	Pickaway	10	A	0.97	20	125.90	140.77	....	1.15	267.82
1913	Pickaway	10	C	1.06	16	66.80	116.74	12.00	....	195.54
1914	Portage	324	H	1.62	12	110.50	57.13	....	20.00	187.63
1914	Portage	326	G	3.94	12	346.50	2.59	....	35.50	384.59
1913	Putnam	134	C	0.41	16 & 20	....	28.00	....	....	28.00
1912 & 1914	Ross	5	A & H	1.83	16	161.26	123.61	....	111.10	295.97
1914	Ross	5	G	0.60	16 & 20	....	27.75	....	21.50	49.25
1912	Ross	29 & 453	C	1.31	16	2.00	174.56	....	111.06	287.62
1914	Ross	258	E	1.00	16	....	85.00	....	29.50	114.50
1914	Ross	361	F	1.00	16	5.75	81.77	....	10.50	98.02
1913	Ross	365	B	1.00	16	....	56.62	....	25.25	81.87
1913	Sandusky	277	A-2	2.18	16	....	31.36	....	....	31.36
1914	Sandusky	277	C	1.09	16	....	15.69	....	....	15.69
1913 & 1914	Summit	98	E	2.38	14	66.56	223.87	....	64.00	354.43
1913	Trumbull	13	B	2.69	12	3,295.25	150.00	148.22	154.00	3,747.47
1912	Washington	7	E	1.00	16	80.00	18.00	4.68	54.00	156.63
1914	Washington	7	F	1.27	16	28.00	23.50	....	13.75	65.25
1914	Washington	7	G	1.29	16	51.25	121.09	3.50	21.25	197.69
1914 & 1915	Washington	393	I	2.23	16	35.75	76.98	....	23.50	136.23
	Grand totals	...	..	27.37	..	$11,891.67	$3,639.25	$169.65	$1.801.61	$17.502.18

*Includes .42 mile of brick.

Total miles—107.11 miles.

No work done on 20.26 miles.

The cracks and joints of one road were filled with a mixture of equal parts of sand and hot tar (Tar T-1). The mixture was made by sifting the dry sand at air temperature into the bucket of hot tar, and then lightly stirring the mixture. The mixture was made in, and poured from the same pouring can ordinarily used in pouring the pure tar. After the mastic was poured into the cracks, it was covered with sand. This work is now in good condition and has all appearances of giving better results than the pure tar.

Method 2—Small Holes and Shallow Depressions in the Surface.—Small holes in the surface are cleaned and filled with the tar and covered with sand in the same manner as the cracks are filled. Shallow depressions and places in the surface which show a tendency to disintegrate are swept clean of all foreign matter and disintegrated material, after which the hot tar is applied to the surface at the rate of ½ to 1 gal. per square yard, and covered with the coarse sand or gravel, slag or stone screenings. The more tar that is used to build up the surface to the required elevation, the more desirable it is to have the coarser grit rather than sand as a covering. Where more than ½ gal. of tar per square yard is required, it is applied in two treatments, the tar each time being covered with screenings. Excess screenings are swept off the first coat of tar before the second application is made.

Method 3—Larger and Deeper Depressions in the Surface.—Larger and deeper depressions in the surface are thoroughly cleaned as described under Method 2, and the surface painted with hot tar. They are then filled with clean, broken stone, preferably of such size that their diameter will be no more than half the depth of the depression to be filled. These stones are tamped and carefully leveled off so as to conform to the proper crown of the road. The voids are then filled with hot tar and the stones covered with screenings, after thorough compacting by tamping or rolling is done, as in the construction of an ordinary tar macadam construction. (Penetration Method.) The same grade of tar is used in Method 3 as in Methods 1 and 2.

Method 4—Where Pavement Is Broken Up.—Where the pavement is broken up, it is cut away with vertical edges and replaced with new concrete of the same quality as that in the good part of the pavement. The vertical edges are thoroughly wet before placing the new concrete, and care is taken to make the new part conform with the remainder of the pavement. The new concrete is kept moist and protected from traffic and frost until it hardens sufficiently, as in case of a new pavement. Defects which have necessitated replacement of small portions of the pavement have been due sometimes to bad concrete and in other instances to a settlement of the foundation.

Method 5—Application of Tar and Screenings to the Entire Surface.—This treatment was applied to many of the first concrete roads constructed by the Department, as a part of the original contract. It consisted in the main of applying from one-third to one-half gallon of tar (Bituminous Material H. T.-1, State Highway Department's specifications), to each square yard of cleaned surface, and covering with torpedo sand. Many of these surface treatments peeled so badly and so soon after being put on that their use as a part of the original pavement was discontinued over two years ago. In but two instances has any attempt been made to maintain this tar surface. One road on which this tar top has been maintained is a 4-in. concrete slab 16 ft. wide constructed in 1912 with the tar surface, and which cracked quite badly. This road was resurfaced in 1913 with the tar and slag screenings for a strip 10 ft. wide in the center. Some minor patches were made during the summers of 1914 and 1915 where the tar had peeled off. On the other road the tar surface is being maintained purely as an experiment. It was resurfaced with tar in 1914, but no repairs whatever were made to the surface in 1915. While this tar top put on as a part of the original contract has in most cases largely come off within a year or so, in a few instances it has remained in place surprisingly well. As one illustration of this, there might be cited a short section of concrete road built in 1912; the tar top put on at that time is still in good condition, it having been replaced in only a few places about the joints and cracks.

In connection with this method of maintenance of concrete roads, it will be of interest to note "Experiment No. 19—Dolarway Pavement." While the tar top on the greater part of the section of road described in this experiment which received but one coat of tar (about .35 gal. per square yard) peeled badly within 6 months after it was applied, the tar top on the 33-ft. section which received two coats of the tar (about .7 gal. per square yard), is still in good condition after over three years' service and having passed through the greater part of four winters.

Still another method of repairing holes in the surface of concrete (and brick) roads and which has been used by the Department in but one instance, is the tamping into the hole of a cold mix of a tar preparation, and stone chips. This same method has been used in the cities of Warren and Ravenna, O. While at this date this method of repair gives promise of excellent results, it is entirely too soon to draw conclusions as to its real value.

On a few of our roads, trouble has come from the heaving of the pavement at the expansion joints, by one slab slipping past and over the adjacent slab. It seems that these heaved joints have been largely caused by the expansion joints having been carelessly constructed in an inclined position instead of a vertical one. It is also possible that the heaving of the joints has been aided by the freezing of a wet subgrade. With an inclined expansion joint it is easy for a slab to shift past the adjacent one when the expansion due to either heat or moisture occurs. This movement would be greatly aided if the frozen and expanded wet subgrade had thawed, thus allowing one slab to drop down before the adjacent slab had settled into position. That the thawing of the subgrade has some bearing on this condition would seem to be indicated by the fact that the heaving of the pavement at the joints usually occurred in March or April. Where this trouble has occurred, a narrow strip of the pavement has been cut away, sufficient to permit the elevated slab to drop back into place, which it has almost invariably done, if not immediately, then after a lapse of a few weeks. This joint is then maintained like others. It frequently happened that the concrete was shattered for several inches back from the joint. In this case a strip of concrete of sufficient width to include all the injured part was cut away and the gap filled with macadam until all danger of further settlement had ceased. Then the temporary filling was taken out and replaced with new concrete, as described in Method 4. It is not deemed necessary in placing the new concrete to construct an expansion joint in connection with it.

Several times during floods a concrete pavement has been undermined as much as 4 ft. from the edge of the pavement. In such instances clay or gravelly clay has been carefully tamped in thin layers back under the pavement. No report has yet reached the office that any such slab has cracked from settlement of this reconstructed subgrade, although some pavements have been thus repaired over two years. It is necessary of course that the tamping be done with great care.

The gang of men used in the repair work usually consisted of a foreman and two to five laborers. Sometimes a wagon loaded with sand accompanied the gang and at other times the sand was wheeled in barrows from piles at the roadside. Almost invariably a 100-gal. tar kettle has been used for heating the tar. Where a wagon loaded with sand accompanied the gang, the tar kettle was connected to and moved with the wagon. When no wagon accompanied the gang, the tar kettle, mounted on two wheels, was pulled by the workmen.

Tar for the repair work was purchased for the entire season at the beginning of the year by competitive bidding. It was then ordered shipped to the various places in such quantities and at such times as wanted on the different roads.

In Table 1 is given a list of the concrete roads maintained by the Department in 1915, together with the cost of the maintenance work. The time actually covered by this table extends from Nov. 15, 1914, to Dec. 31, 1915, or 13½ months. It will be observed that the cost data are separated into the four items of roadbed, surface, bridges and culverts, and superintendence. The item of surface includes all expenses incurred against the concrete slab outside of the superintendence. If a tar kettle was purchased, for instance, it was charged against the surface of the road on which it was intended to be used.

EXPERIENCES OPERATING MILES CITY WATER SYSTEM DURING 45 CONSECUTIVE DAYS BELOW ZERO.

By G. C. Pruett, City Engineer, Miles City, Montana.

The past winter was the coldest of which there is record in the State of Montana. The extreme cold of 48° below zero had never been reached but once since the establishment of a weather office in Miles City some 30 years ago, and the long continued extreme cold spell, 45 consecutive days below zero, had never been experienced before. The cold weather started about the middle of December when we had considerable snow, with the temperature around zero from then until the first of January. January and half of February were continually below zero with a slight break from the 15th to the 25th of February, then more zero days to the 5th of March. All told we had 60 days below zero minimum temperature during the winter, most of which were from 15° to 30° below. During this time we had a great deal of snow. It often snowed when the thermometer stood at 20° below zero, which is very unusual for this section where it seldom snows after the thermometer reaches zero.

Meter Troubles.—We began having meter trouble on the 11th and 12th of January when the thermometer reached 46° below zero on the 11th and followed up on the 12th with 48° below. On those two days we removed 30 frozen meters from basements out of a total of 950 in service. These meters were all left out until the cold weather let up. They were replaced with pieces of pipe cut to the exact length of the meter and connected between the meter connections. From the 12th of January to March 1st we removed 25 others, making a total of 55 meters removed on account of freeze ups, and 15 from other premises where there was danger of freezing. Fifty of these were replaced in three days by two men after the 1st of March. The balance being underground installations were not replaced until between March 25th and April 1st. They were replaced at the rate of five per day by the same two men.

The damage done to the meters was comparatively small; only one meter was completely ruined, six had their intermediate gears spoiled, eight had stems connecting intermediate and register gears twisted off, the balance merely had the frost bottoms bursted or the flanges sprung. All meters were easily repaired at a nominal expense. The total cost for labor, material and testing (all were tested before being replaced) amounted to a trifle less than $150, or, based on the total meters in service, 15.8 ct. per meter.

Frozen Services.—Our service trouble started about February 1st and reached a maximum about February 15th, gradually decreasing until March 10th when it ceased. All told we had 130 services frozen outside of basements during the winter, but inasmuch as several of these were frozen two or three times during that period, the actual number of services involved was a little less than 100, or approximately 10 per cent of the total in use.

The principal places of trouble we found to be at the gooseneck and at the curb box with several frozen at the gutter line.

While the city does not assume the responsibility of thawing or taking care of the service pipes, it being the duty of the individual consumer to lay and maintain the service from the main, we found it necessary last winter to take charge of the thawing because the plumbers lacked proper equipment for doing the work.

Electric Thawing.—The frost was so deep and so hard that an attempt to expose the pipe by digging down to it meant considerable delay in re-establishing service. For that reason the city purchased the necessary equipment which consisted of one 1,100 to 50 volt transformer, cable, meter, switches, choke coil, etc., and constructed an electric thawing apparatus. The whole equipment was placed on a trailer and pulled by a Ford roadster. In thawing connection was made to the electric mains, the current stepped down to 50 volts and connections made to the house water system and the nearest fire hydrant. The amount of current was controlled by the choke coil and checked by an ammeter in the thawing circuit. For ¾-in. services the current was not allowed to exceed 150 amperes, and at this rate a service which had not been frozen more than a day was thawed in about 20 or 30 minutes, although we had some cases requiring one to three hours. With that amount of current it was also not possible to thaw frozen goosenecks. These were thawed by digging them up or by using a portable steam rig as described later.

The reason for limiting the current to 150 amperes was because by trial this was found to be the maximum which could be successfully used without danger of causing the pipe or gooseneck to burst. Heavier currents melted the wiping between the lead and brass or heated the pipe so quickly as to cause it to break. After a little experimenting we broke only one connection in about 100 thawed.

The charge made for thawing was $5 per hour or connection and $5 for each hour after the first, i. e., the minimum charge was $5. This only covered the rent of the rig and three men to handle it who were employes of the City Light Department. In addition to this the consumer was required to have a plumber to take care of any pipe work and look after leaks in case any should develop.

Frozen Mains.—We also had some trouble with hydrants and mains. The first main froze on February 20th, it being a long dead end with few consumers. The point where it froze was at a bend where a run off had been graded in the street and the pipe left with about 4½ ft. cover.

Steam Thawing.—The freeze was limited to a section about 100 ft. long and was thawed with a portable 8-h.p. steamer mounted on a sled. Holes were first driven down to the pipe about 20 ft. apart by means of 1-in. drills pounded down with a sledge hammer. Steam was shot into these holes until the frost was drawn and then the pipe uncovered at these holes in sections of about 5 ft. Short pieces of pipe were then worked along the top of the water pipe and thoroughly steamed from one hole to the next. The main was tapped to locate the frozen section and the steaming process continued from hole to hole until the main was opened. It did not break and gave no further trouble from freezing, although the frost was below the main before it was steamed.

About the time this first section was opened two other sections froze the same day. One of these was also a dead end and the other a connected circuit where the street had been graded down until there was little more than a 4-ft. cover on the pipe. This latter was a considerable stretch—about 400 ft. The first of these was thawed as described above. It was sufficiently deep, compared with other sections of town where we had no trouble, but the soil was a gravel sand, very porous, from about 12 in. of the top. The top 12 in. was light loam. This material was not frozen hard; in fact, it could be spaded without picking after the first 2 ft., but handfuls of it around the pipe showed frost crystals. One length of pipe was split.

The other freeze up of these two was uncovered the whole distance. First the section was valved off so as not to interfere with the service in the balance of the district, then the frost drawn by means of steaming holes drilled 10 ft. apart as described above. Five split joints were found in this section and after being replaced the whole pipe was lowered 18 in. Only two joints in the 400 ft. showed leakage from the lowering and they were only seepage leaks.

The cost for this work was as follows:

Steaming	$ 40.00
Cutting in two valves	18.50
Repairing main	13.00
Lowering main, including uncovering and backfill	120.00
Total labor	$191.50
Material	52.00
Total	$243.50

Labor $3 per day for 8 hours. Foreman $4 per day, team without driver $3 per day. No rent charged for steamer or tools.

The only other place where we had trouble was on a street where the pipe had a $5\frac{1}{2}$-ft. cover and mostly loamy soil which would not be expected to freeze so deep, but on account of the poor surface drainage we found good 6 ft. of frost. This was the deepest frost found. We had no difficulty in steaming it out and after replacing one split pipe in a run of 120 ft. we had no further trouble.

The total cost of taking care of our 20 miles of mains on account of freezing was $650 or $32.50 per mile.

Frozen Hydrants.—The fire hydrants presented a new problem in my experience. Heretofore our trouble has been limited to water freezing in the barrels due to leaky valves and poor drainage. While we have not had a great deal of trouble in the past, what we did have could be traced to one of these causes.

Last winter we not only had these troubles to contend with, but also trouble with the connections freezing adjacent to the valves. During the winter we found only two hydrants frozen in the barrels and 20 frozen just outside of the valve out of a total of 150. Some of these 20 froze more than once after being thawed.

The thawing was done with the portable steamer by hooking directly onto the nozzle with a cap tapped and connected with the steam hose. The hydrant was left closed to blow the steam—which was carried at 50 lb. for this work—out through the drain opening. This not only warmed up the hydrant and pipe but the ground around the hydrant also. It took about 10 minutes per hydrant on an average. As soon as this trouble developed we went over all of them each week and steamed them whether they were frozen or not.

The cost for three general steamings and the special attention given to the bad ones cost $120 at the wages stated above, but not including boiler rent, or an average of 80 ct. per hydrant.

It has been our practice to crate the bad hydrants each winter and pack them with dry straw manure. We have probably averaged crating 15 each winter, but last winter this apparently did no good; besides it froze so solid one needed a pick to get to the hydrant.

The frost last winter averaged about 2 ft. deeper than we have had it before, probably accounted for by reason of the heavy soaking rains throughout the fall and early part of the winter. The ground went into the winter with more moisture than I have seen before and notwithstanding the heavy covering of snow, the frost went down very easily. I am of the opinion that if the ground had been ordinarily dry when the snow fell, we would not have had an unusual depth of frost.

AN OFFICE SYSTEM FOR COUNTY HIGHWAY ENGINEERS.[*]

By H. N. Legreid, County Highway Engineer, Humboldt County, Iowa.

Records of various kinds pertaining to permanent road and bridge improvement are made by the county highway engineer in the discharge of his duties in connection with such improvements. Records of permanent road improvement include field notes of surveys preliminary to permanent construction; records of cornerstones; records of design, estimate of cost and contract and construction data; plans and profiles; construction and inspection field notes, and records of cost. The records of permanent bridge improvement include practically the same classes.

The adoption of some system for indexing and filing these records, and the selection of the proper appliances and methods for carrying out this system are the means by which time and energy wasted in the filing, finding and use of such records is reduced to a minimum. The system to be described is one that has been found to be adapted to the records and characteristic requirements of the county engineer.

The unit used as a basis for indexing and filing road records is a section of the county road system. The highway law of this state requires that the county road system be divided into sections of a mile or thereabout, and one such section is the logical unit for any system of indexing and filing. These sections are designated numerically, the numbers from 1 to 200 being reserved for the county roads, and those above 200 for township roads. A number is assigned to a section when the first survey for permanent work is made upon it. This number is placed adjacent to the section of road on a small county map, and on the back of the map the number of the section and its location are entered. For purposes of indexing and filing, the number is also placed on all records pertaining to the section, and for the reverse operation of finding, the index map is referred to for the section number.

This description is sufficient to indicate the main features of the system; but the appliances and methods used for each class of record in carrying out the system also deserve some attention.

Field notes of road surveys preliminary to permanent construction are recorded in loose leaf field books, the loose sheets being given the section number of the road, and a page number. When preliminary notes are no longer needed, they are filed in a tabbed folder bearing the road number. In this way, all notes pertaining to a section are collected in one place, a thing which cannot be easily done with bound books.

In making preliminary surveys it is highly desirable to find section and quarter-corner stones, and they are diligently hunted for. If they are found, tie measurements are taken from them to various objects and recorded. On a white print map of each township in the county the tie measurements of each cornerstone found are entered at the proper location. These prints are carried in the field for purposes of reference, and eliminate the need of looking up notes of old preliminary surveys for this information.

All computations connected with the design of permanent improvements are kept in a bound book, indexed by section number and page for each job. The final design and estimate of cost are filed in a letter-size folder, indexed by number, and this folder is also used for filing all data connected with the contract and construction period.

Profiles and plans showing permanent improvement proposed for each section are filed flat in a large cabinet with shallow drawers, different drawers being used for county and township roads. Profiles are filed in numerical order.

Field notes required for staking out and inspecting permanent work are carried in loose leaf binders. The number of binders used is sufficient to carry into the field, if necessary, all the notes pertaining to all the work being carried on in the county. Notes connected with the work in one township, or several adjacent townships, are carried in one binder, depending on the bulk, and the notes are not removed from the binder until the work is completed or the notes are needed in the office. It is seldom that more than two binders are carried for a day's trip. In addition to the field notes, a card for each job is carried in the field book, this card being used in the field for brief reports of inspection, and in the office as a reminder and follow up. After construction work is completed and paid for, the construction and inspection field notes are filed in the field note folder for the section.

---

[*] Extract from a paper presented at the annual meeting of the Iowa Engineering Society.

The bills for permanent work on county roads which have been presented to the board of supervisors, and allowed by them, constitute the source from which the costs of such work are obtained. These items of cost which have been incurred for work or materials are entered in a claim register. Name of the claimant, location and nature of the work are entered, and amounts claimed on the same bill for items on different sections of road are charged to the respective sections. The form used in the claim register also allows of a distribution of the costs according to the classification of work issued by the Highway Commission. From the claim register the costs are posted to the book of final entry, the county road record. This is loose leaf, one sheet being used for each section of road. All costs incurred in the permanent improvement of a section are entered and classified under permanent grading, drainage and surfacing.

Costs of permanent work done on township roads are obtained from the bills presented to the engineer for his certificate, which the law requires must be on such bills before allowance by the board of trustees. This offers an opportunity for making a record of such costs, and the same books are used as for county roads.

The system used for records on permanent bridge work differs so little from the one just outlined for roads that the details concerning it would be repetition. The numerical system is used, and all records on a structure are filed and bound by number.

CONSTRUCTION OF GRAVEL ROADS BY THE FEATHER EDGE METHOD.*

By H. E. Bilger, Road Engineer, Illinois State Highway Department
Springfield, Ill.

There are two general methods of gravel road construction, namely, the trench method and the feather-edge method. Certain combinations of conditions prompt the use of these respective methods, and it is necessary that a thorough study of these conditions be made before the particular method of construction is adopted.

The trench method naturally lends itself to dry weather conditions, and also to soils of such character as will not readily mix up into a mud when brought in contact with a little water, as gravelly or sandy soils, and even certain loose clay soils. For the successful use of the trench method there should be provided entirely adequate facilities for surface drainage during the construction of the road. If this is not done the excavated trench becomes in wet weather a virtual stream bed which is practically worthless so far as supporting the gravel is concerned. There is also some relation between the character of the gravel to be used and the method of construction, whether of the trench or the feather edge. Weather and soil conditions being favorable, the trench method can be used with greater satisfaction with bank gravel than with river gravel. The reason for this is that the bank gravel will become consolidated and form a practically impervious surface to shed water from the subgrade in a much shorter time than will be the case with river gravel. The trench method is the more expensive method of construction, however, and unless conditions are strongly in its favor, it is believed that better results will be obtained eventually by the use of the feather-edge method.

The conditions that encourage the use of the feather-edge method are practically the opposite from those that encourage the trench method. If traffic conditions must be contended with during the construction of the road it will usually be found that other things being equal the feather-edge method is preferable. This method will now be considered in some detail.

The Roadbed.—Before any gravel is hauled on to the road, the cross-section of the road should be brought to the requirements of the plans and the entire width of the graded roadway should be thoroughly rolled until it is of practically a uniform density at all places. At least the portion of this roadway that is to form the subgrade for the gravel should be dry, compact, almost perfectly smooth, and should have such cross slope as may be necessary to shed readily any surface water that might fall thereon. The rolling should preferably be done with a three-wheel self-propelling roller weighing from about 300 to 400 lb. per inch of width of tread on one rear wheel. If such a roller is not readily available, a tractor of similar design and having approximately the same weight will usually answer the purpose very well. During the process of rolling it will often appear to be entirely unnecessary and in fact it frequently is, but the purpose of the rolling is quite as much to detect the location of soft and yielding spots as it is to consolidate the roadbed generally. It is essential that these spots be detected before gravel is placed upon the road. When they are detected additional material should be added until the yielding ceases, and it may even be discovered that water pockets some distance beneath the ground surface will need to be released to an open channel. There should not be left on the graded roadway at any time berms of earth or other material that would interfere with the immediate drainage of its surface.

The work of placing the gravel upon the roadbed might begin at either end of the road, but it should be carried on continuously to the other end. During the process of construction and before any particular section of the road is completed the gravel might be subjected to the traffic of the vehicles used in further construction. Should such traffic rut or displace the gravel, the same should be reshaped and re-rolled before further work is done toward the completion of the road.

Two Course Construction.—When the bonding material in the gravel is not entirely satisfactory with respect to both quality and quantity, it is usually advisable that two course construction be adopted. Whether or not the work is to be done by contract, it is important that there be used some positive and accurate method of determining the volume of gravel delivered upon the roadbed. There are several methods by which this can be accomplished, but experience seems to indicate that by the use of temporary side board forms the desired results can be assured and this method is not uneconomical.

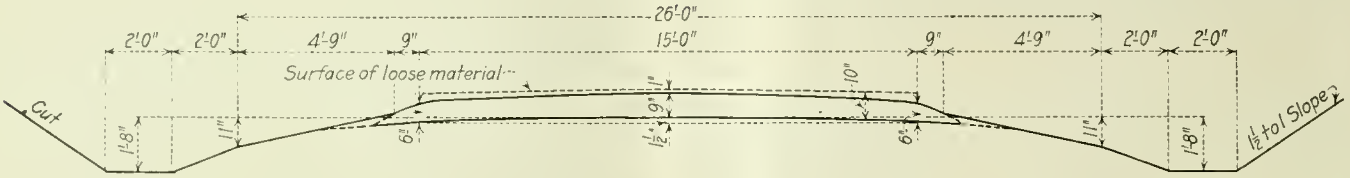
Upon the satisfactory completion of the road-bed there should be set thereon, true to line and grade, temporary side forms having a width equal to the depth of the loose gravel which should be shown on the plans. These boards should be held in place by stakes at such intervals as will prevent lateral deflection greater than about 3 in. from the true alignment. Whether the gravel is to be hauled by wagons, motor trucks, industrial railways, or other vehicles, it might be dumped directly upon the subgrade. After there has been placed upon the subgrade a sufficient quantity of gravel for the lower half of the road, it should be distributed to a uniform depth by the use of a blade-grader, drag scraper, or otherwise. While this course is being spread, all the larger stones should be raked or otherwise placed directly in contact with the subgrade. Upon this course of gravel there should be placed such an amount of bonding clay as may be necessary in order that the gravel will comply with the specifications. After the gravel has been spread it should be thoroughly harrowed several times over until the cores formed by dumping it have been entirely loosened up to a density equal to that in the other portions of the gravel. The importance of this thorough harrowing can scarcely be over-estimated for in order to secure the best results it is essential that the voids in the gravel be reduced to a minimum, which means that a maximum density of material must be obtained, and this density is closely approached by harrowing until the pebbles of the several sizes become so placed as to occupy the spaces between those of a large size. The cost of this harrowing as compared with the results obtained is practically negligible, and if necessary it would actually be more advisable to do away with the rolling and retain the harrowing than to do away with the harrowing and retain the rolling. The harrow should be of the stiff tooth type, and should have metal teeth at least 1 in. diameter extending about 6 in. below frame. The spacing of teeth should be such as will admit of the free passage of the stones between them, and yet so displace them as to produce the density desired. The design of the harrow should provide a weight of from 8 to 12 pounds upon each tooth.

---

*Extract from a paper presented at the Conference on Highway Engineering at Kansas State Agricultural College, Manhattan, Kan.

After the second course of gravel has been placed, it should be spread until its upper surface comes flush with the top of the side forms and its cross section conforms to that shown on the plans for loose gravel. The forms should then be removed and the gravel allowed to take its natural position. Upon this second course there should be distributed the necessary quantity of bonding clay. It should then be thoroughly harrowed several times over, as before, until the cores formed by dumping the gravel have been entirely loosened up and the clay has been uniformly distributed throughout. The harrowing should continue until a uniform density of material is obtained throughout the upper course.

Having done this, the earth shoulders should be shaped by the necessary cutting and filling until the cross section conforms approximately to the finished work as the plans provide. Material other than the natural earth should not be used in forming these shoulders, and all vegetable matter should be strictly prohibited from entering into the work. Upon having shaped the shoulders, the graded roadway over the entire width should be rolled several times over until it is thoroughly compacted, foming a firm, smooth surface, free from waves and according to the requirements of the plans. The rolling should begin at the extreme outer edges of the shoulders and should work toward the center, at each rolling of the gravel allowing an overlap of one-half of the width of one of the rear wheels, and each wheel should cover the entire gravel surface.



Section of Gravel Road Built by Feather Edge Method.

Should the condition of the gravel or its bonding material be such as not to compact readily under the action of the roller, sprinkling or other means should be employed to compact the gravel as the engineer may direct. The speed of the roller should not exceed about 100 ft. per minute. It is quite probable that after rolling there will appear either on the shoulders or the gravel certain depressions and other irregularities. To correct these defects suitable material should be added or removed and they should then be re-rolled. The finished surface should conform to the cross-section shown on the plan and should present a smooth and even appearance. Should the gravel, with its natural or artificial mixture of bonding clay, for the upper four inches of the road, be of such a character that it will not insure a satisfactory wearing surface with a dense body and uniform texture, a 1-in. coating of bonding gravel should be applied uniformly over the entire surface of the gravel road. This bonding gravel should then be raked and rolled into the road surface until all the interstices are filled and the surface is smooth, of a uniform texture and free from waves.

One Course Construction.—When the conditions and materials are reasonably suitable, there can be built with one course construction a gravel road that will in all respects prove equally satisfactory with one built by the two course process. If the gravel contains naturally a sufficient quantity of satisfactory bonding material, one course construction will generally prove the more economical. When so employed the gravel might be dumped upon the road-bed and then be spread with a blade grader, drag scraper, hand rakes, or otherwise until the material at the edges comes flush with the temporary forms. The forms should then be removed and the gravel thoroughly harrowed several times over until the cores formed by dumping the gravel have been entirely loosened up and the upper 4 in. has a uniform density. Otherwise the process for two course work would apply also to the one course.

Special Features of Gravel Roads.—Unlike most types of roads, the gravel road is not yet completed when it might appear that all work has been done. Satisfactory gravel road construction being distinctly a process, it is seldom an operation that can be completed within a given period of time, however much skill and energy may be devoted to the work. Aside from the usual maintenance required for all types of roads, there is required in addition for the gravel road that it receive attention at times for a period of some three to six months from the date of supposed completion.

When the gravel road is compared with the waterbound macadam it is evident why this additional care must be given to the gravel road. The bond in a waterbound macadam road is both mechanical and chemical. It is mechanical in the sense that the angular pieces of stone interlock with one another and become firmly keyed together under the action of the roller. The bond is also chemical as a result of the action set up by the presence of water in contact with the fine material in the stone. As contrasted with this it is evident that the mechanical bond is lacking in gravel roads. In the first place, the gravel pebbles are approximately round, and in addition their surface has been worn almost perfectly smooth by the action of water. Clean and smooth gravel pebbles simply act like so many marbles in tending to roll over one another and being slow to consolidate. It is clear, then, that the bond in a gravel road is almost entirely chemical and comes about from the clay content and also from the crushing of the gravel into finer particles under the action of the roller and the traffic. Inasmuch as the gravel pebbles are usually from a rather hard stone as compared with limestone, there is required considerable team traffic on gravel roads before any of the pebbles become sufficiently pulverized to supply the bonding material corresponding to screenings in macadam roads.

After having become thoroughly consolidated gravel roads as a rule are more serviceable and more satisfactory than limestone waterbound macadam roads. As for comfort of travel the gravel road more nearly approaches that of an earth road in perfect condition than does the macadam road. The bonding clay content of the gravel road makes it somewhat more resilient, and consequently more desirable for travel than a rigid road. In dry or windy weather, gravel roads seldom become as dusty as macadam roads, and so from this point of view also they are more satisfactory. Gravel roads can withstand the ravages of a long spell of dry weather much better than can macadam roads.

For gravel road construction there is not required the skill or experience necessary for the other types. In fact, as regards both construction and maintenance, the very nature of the road itself is such as to be more nearly in harmony with the conditions, customs, practices, etc., prevailing in rural territory than all other types of roads except the earth road. For ordinary traffic conditions gravel road maintenance scarcely ever need consist of anything more than the addition of a little more gravel and the dragging of the road with an ordinary drag just as earth roads are cared for. This simple process with a simple equipment makes the gravel road highly adaptable to conditions that are strictly rural.

METHODS EMPLOYED IN SPANNING THE TREACHEROUS BRAZOS RIVER WITH TWO 10-IN. GAS MAINS.

Contributed by C. R. Sutton, 4131 Cornelius Ave., Indianapolis, Ind.

A gas main construction job presenting interesting features was recently completed at Waco, Texas. Two mains of extra heavy pipe, of ⅜-in. wall and 10-in. diameter, were laid across the Brazos River under unusual difficulties.

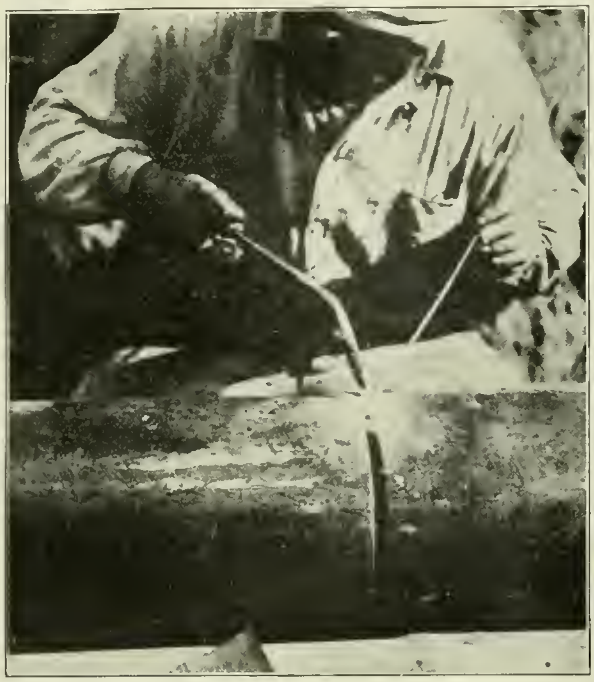
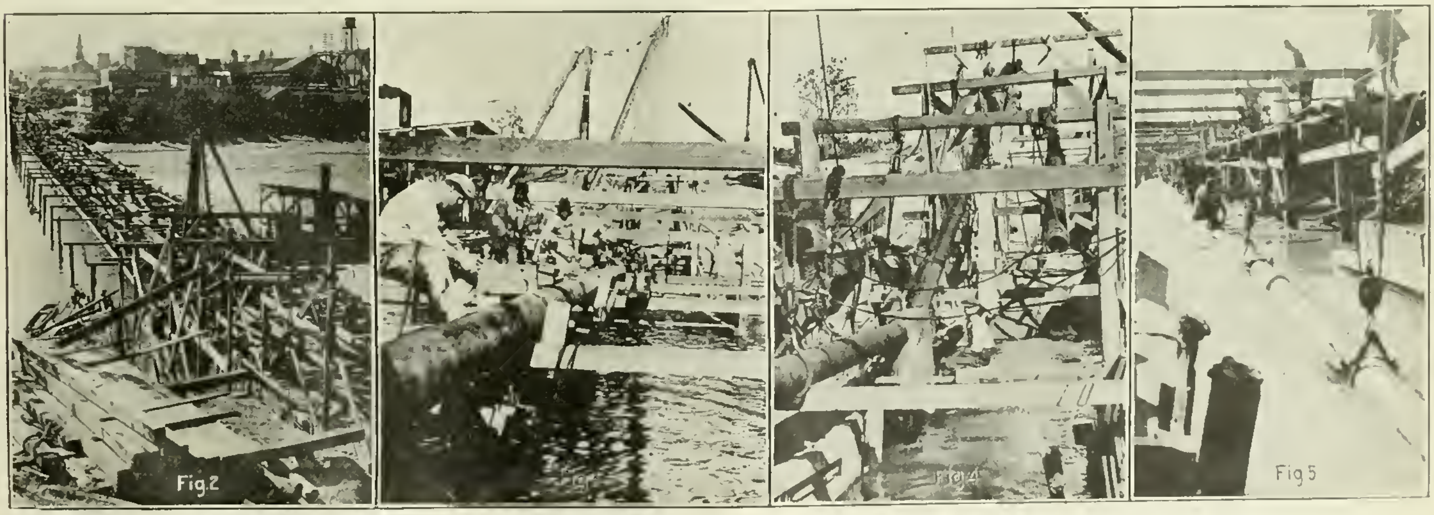


Fig. 1—Joining Two 20-ft. Sections of Extra Heavy Pipe ⅜ in. Thick and 10 in. Diameter, by Means of Prest-O-Lite Oxy-Acetylene Process.

Owing to the fact that the Brazos River at this point frequently rises very suddenly, extreme caution had to be exercised in proceeding with the work in order to guard against the pipe and temporary false work being washed away.

Another problem which presented itself for solution by the engineers in charge was the fact that the entire river bottom was covered with deep layers of quicksand.



VIEWS SHOWING THE LAYING OF TWO LINES OF 10-IN. GAS MAINS ACROSS THE BRAZOS RIVER.

Fig. 2—General View of False Work and Suspended Gas Main Across Brazos River. Fig. 3—Another View of Operator Welding Together 100-ft. Lengths. Fig. 4—Finishing Installation of Drip Pocket for First Pipe Line; Pipe Ready to Drop Into Water. Fig. 5—Preparing 115-lb. Weights of Scrap Steel Piling to Sink Welded Main.

In spite of these natural barriers, the job was undertaken and completed without a hitch in the original plans. According to reports received lately from Waco, the pipe lines are working satisfactorily in every respect and the engineers who superintended the work are highly elated over the success of the undertaking.

Preliminary to starting this river crossing work, which also included the installation of twelve submarine cables, it was most important to ascertain accurately at what depth below river bottom the gas mains and cables would have to be installed to prevent them from being washed out. It was learned during the construction of the new East Waco power plant that the formation of the ground above bedrock was uniform in that section of the country. Immediately overlying the rock are 8 to 10 ft. of coarse sand and gravel, and above this strata there are alternate layers of quicksand, clay, and fine sharp sand. Test holes drilled across the river, on the center line of the crossing, confirmed this information; the river bottom was all quicksand above the gravel.

It was therefore essential to safety that the pipes and cables be laid well into the top of the gravel strata and firmly anchored therein. To attain this it was necessary to excavate a ditch through about 12 ft. of quicksand and into the gravel strata, all the way across the river bed. This required the installation, on the up-stream side of the ditch, of a substantial false work across the river, on which a combined pile driver and derrick could be moved back and forth as the work progressed. Wakefield piles were driven on the up-stream side of the pipe and cable ditch and across the river to protect the excavated ditch from cavings. The Wakefield piles were in turn braced back to the false work, which was sufficiently strong to take up the pressure on the piling.

It was not thought advisable to run the chance of having the pipe washed away from the top of the false work by a sudden rise of the river and the 20-ft. lengths of pipe were therefore first welded together by the Prest-O-Lite oxy-acetylene process into 100-ft. sections in the pipe ditch on the west side of the river, well above the water line.

A close view of the oxy-acetylene welding operation is shown in Fig. 1, the gas supply (oxygen and acetylene) being furnished from portable cylinders which were moved from point to point as the work progressed. Owing to the fact that beveled end pipe had not been ordered, it was necessary to set the pipe lengths about ⅜ in. apart so as to make a butt weld, using Norway iron welding wire as a filler, fusing the two edges into a homogeneous structure of metal. It required about 45 minutes to make each joint on the unbeveled 10-in. pipe. In making a welded joint on 10-in. steel pipe with the ends beveled at a 45° angle, as now furnished by the leading pipe manufacturers, it is found that only 30 minutes are required, using about 35 cu. ft. of compressed oxygen and 21 cu. ft. of compressed acetylene. About 14 ounces of filling material are also required, making a total cost of $1.10

for making a joint in this size pipe by the oxy-acetylene process.

These welds were first tested for strength by placing a block under the joint. The weight of two men was supported, one at either end, without affecting the joint, in spite of the leverage of the combined weight of the pipe itself and the men at the ends. A pressure test was later given each welded section by subjecting them to 90 lb. gas pressure without the sign of a leak.

A partial view of the ditch in which the pipe was welded into 100-ft. sections is shown in Fig. 2 and also a broader view, showing the false work that extended across the river. The compressed oxygen and Prest-O-Lite dissolved acetylene used in making the welds were drawn from cylindrical containers set at convenient points as the work progressed. After the 100-ft. lengths of the submarine section of the gas mains had been welded together in the pipe ditch at the side of the river, at about the same level with the top of the false work, they were pulled out over the false work for the final welds which were made in the shortest possible time. While making the final welds the portable steel cylinder of oxygen and acetylene was conveniently perched out on the cross members of the false work.

Figure 3 shows the operator completing the joining of the 100-ft. sections ready for welding to the drip pocket. It will be noted that the welder is followed by a workman painting the pipe with an asphalt coating. Burlap was then wrapped around the pipe and coated with asphalt. A second wrapping of burlap was then given, with a final coat of asphalt.

Figure 4 shows the 10-in. main being welded to the drip pocket, and also the outlet pipe welded into the top of the drip pocket. When the cast iron drip pockets were received from a point in the central states it was found that they could not be used because these castings were full of tiny sand or blow-holes. There would have been a very serious delay had it been necessary to await new cast drip pockets, but the oxy-acetylene process was called on to meet the emergency, and the two drip pockets were quickly and economically made from boiler plate on hand, using the oxy-acetylene cutting blow-pipe for cutting the boiler plate to proper size. By welding all seams with the welding blow-pipe, stronger and neater seams than could be obtained by the former laborious method of punching and riveting were made possible. The new drip pockets were 24 in. in diameter and $5\frac{1}{2}$ ft. high when completed.

Figure 5 shows the entire length of pipe, 550 ft., required to span the river with the drip pockets welded on, tested, coated, and lowered into the water. To many it seemed certain that this heavy bulk of metal would surely sink to the bottom when lowered into the water, but true to the assertion of the engineers in charge, it floated on the surface as shown in Fig. 5. The oxy-acetylene cutting blow-pipe was called into use again in cutting up steel piling into the proper lengths in order that 115 lb. of dead weight might be attached to each 20-ft. length of pipe and cause the main to sink to the bottom of the trench in the river bed.

The second 10-in. main to be laid across the river was constructed in the same manner as described above and is shown completed and ready to be lowered into the river in Fig. 2. This picture also gives a good view of the entire length of false work which it was necessary to construct across the river.

Both pipe lines on coming up from the bed of the river were welded onto the extension that connects them to the city mains. Very material savings in time and operating costs were effected by the use of the oxy-acetylene process in the work described above and in making up the many special fittings required, thus enabling the completion of the work in an unusually good time and a satisfactory manner. This installation was superintended by the Phoenix Construction Company of New York, under the direction of Mr. B. Diem, Engineer.

PROFITABLE WATER WORKS IN WISCONSIN VILLAGES.

The accompanying table gives a list of Wisconsin villages in which the public water supply system showed a net profit, for the fiscal year, after paying all expenses and interest on the funded debt.

TABLE I.—ANNUAL PROFIT IN 35 WISCONSIN VILLAGE WATER WORKS.

City.	Population.	Net profits.
Elkhart Lake	199	$ 438 75
Kilbourn	1,170	1,411.21
Boyd	527	410.42
Cashton	568	193.03
Clinton	897	715.27
Cumberland	1,445	1,454.44
Ellsworth	1,005	114.29
Fennimore	1,159	255.76
Galesville	973	162.66
Lodi	1,044	732.51
Mazomanie	917	123.23
New Glarus	708	696.31
Onalaska	1,146	595.39
Shullsburg	879	285.30
Sun Prairie	1,119	254 58
Waterford	581	1,087.58
West Salem	840	507.39
Alma Center	417	54.24
Avoca	436	220.00
Baldwin	584	205.29
Bellemont	532	83.82
Benton	652	14.45
Blair	486	132.86
Blanchardville	645	176.98
Cambridge	507	533.63
Cameron	562	462.66
Colby	869	298.55
Deerfield	533	39.98
Independence	664	262.29
Kiel	1,244	180.72
Merrillan	625	11.48
Middleton	679	527.87
Viola	671	202.00
Whitehall	703	148.52
Wonowoc	789	672.69

These data are significant; they show that very small villages can afford public water supplies.

Foul Water Mains.—During a typhoid fever epidemic at Monroe, Mich., in the summer of 1915 the water mains were thoroughly flushed preparatory to treating the supply with hypochlorite of lime. There are 160 hydrants in all. The workmen were instructed to let the water run at each hydrant until it became clear. The maximum time of flushing on any hydrant was 147 minutes, the minimum 3 minutes, and the average time $22\frac{1}{2}$ minutes. These figures are very conclusive in showing that an enormous amount of sediment had accumulated in the mains. The discharge for the first few minutes from practically all the hydrants was very black turbid water; then the water became more yellowish in appearance and finally cleared up. The suspended solids in this first discharge displayed the property of readily settling out in a test glass and were more sandy in nature than the light and not so readily settleable suspended solids which emerged during the remainder of the muddy water flow. The results from the flushing of the water mains were proof of the fact that Monroe was using a raw water which was undoubtedly very objectionable in times of freshet on account of its physical imperfections. The supply is obtained from the western end of Lake Erie at a point 1,800 ft. off shore and in water 14 ft. deep.

Woman Carries Typhoid Germs for 29 Years.—It has been established by the Michigan State Board of Health that the typhoid fever cases on Mackinac Island in the summer of 1915 were caused by drinking milk which had been contaminated by a woman who had carried the specific germs of the disease in her system during the unusual period of 29 years. Flies carried the germs from an open privy vault to the shed in which the milk cans and bottles were stored. The distance from the privy to this shed was but 20 ft. The case is fully treated in the Bulletin of the Michigan State Board of Health for February, 1916.

San Francisco Dry Dock.—The first contract for constructing the world's largest dry dock, for the Union Iron Works, was awarded the San Francisco Bridge Co. on May 2. It is to be 1,000 ft. long, 125 ft. wide and 45 ft. deep and will cost $2,000,000.

Engineering and Contracting

**Devoted to the Economics of Civil Engineering Design
and to Methods and Cost of Construction**

EDITORS
H. P. Gillette C. S. Hill C. T. Murray S. C. Hadden C. W. Malcolm

Volume XLV. CHICAGO, ILL., MAY 17, 1916. Number 20.

CAN NATURAL CEMENT "COME BACK"?

This question is raised by one of the great natural cement manufacturers, whose evident purpose is to make answer in the affirmative.

Utica cement was first put on the market in 1838—almost 80 years ago, and numberless structures built in those early days bear witness to the durable quality of that cement. On its durability there can be no question. What, then, has led to the decreased use of natural cement during the past fifteen years? Probably the drop in price of Portland cement has been the main reason, but also there has developed among engineers a tendency to select the strongest cement regardless of price.

For reinforced concrete work a very strong cement is essential, but there are many kinds of engineering structures where strength sufficient to carry but little more than their own weight is all that is needed. Retaining walls, dams, sewers, pavement bases and building foundations fall within this class. For all such structures cost per cubic yard of masonry of only moderate strength and of sufficient density is the only criterion that should be applied. Yet without doubt the cement for most of that sort of work is specified without adequate study of unit costs.

To give a good illustration, take a base for brick or asphalt pavement. It is known to most highway engineers that some of the best pavements of those types have been laid on old macadam. It is also known that macadam has very slight strength—tensile, transverse or compressive—yet sufficient for the purpose of distributing wheel loads over the subsoil. Natural cement concrete, even when very lean in cement, has far greater strength than macadam. Hence it follows that a cheap yet sufficiently strong and dense pavement base can be made with natural cement wherever freight charges on the cement are not high. The same holds of nearly all classes of foundations.

Retaining walls and dams of massive design are extensively used, and there, too, it is known that density and mass, not strength, are the desiderata. Hence the designer of such structures should aim to get the desired mass at the least possible cost. In the case of some retaining walls this has been accomplished by the use of "dry rubble," rubble containing no mortar at all. In the case of some dams—the "rockfill" type—no mortar whatever has been used in the body of the dam. Those are extreme types of masonry, but they serve admirably to illustrate our point, namely, that **strength is not the criterion by which all types of masonry should be judged.**

To make masonry waterproof one of the most effective ways is to use a superabundance of hydraulic cement, so as to insure perfect filling of the voids in the sand. But a 1 to 1 or 1 to 1.5 mixture of cement and sand is expensive where a high priced cement is used. Is not the answer to be found in many cases by using low priced cement for such rich mixtures? Did not the early engineers use better judgment than those who today use rich mixtures of higher priced cement?

If natural cement is to "come back" it must be because with it there can be secured either greater density or the desired mass at less unit cost than with Portland cement. We deem it important in this connection, therefore, to point out that for many kinds of engineering structures either density or mass is the chief desideratum and not strength.

WHY THE RIVER AND HARBOR BILL IS BEING FOUGHT.

River and harbor improvement has a legitimate claim on the Federal treasury. A sum of $40,000,000 a year expended in river and harbor improvement in the United States and their possessions is not excessive. Neither of these statements will be generally disputed. Yet the river and harbor improvement appropriation bill calling for $40,000,000 expenditure is being bitterly opposed in Congress and in the newspaper press of the country. There is scarcely an engineering or contracting journal that has not voiced criticism of the bill. It is an open target for the cartoonist and joke monger. Why does this condition exist? Nearly anyone can answer correctly. Indeed, the question is so elementary that one puts it apologetically. It must be asked, however, and asked until the correct answer stands clear and high on its pedestal of absurdity. Congressional river and harbor appropriations are criticised and opposed because they are made without regard to business or economic needs by an agency (Congress) unequipped to determine and evaluate these needs.

PUBLIC WORKS CONSTRUCTION AT THE END OF THE WAR.

We do not care to prophesy what form and direction the disturbing factors will take at the end of the European war. While our guess is as good as another's it isn't any better and remains only a guess. Many dire happenings are being predicted. Of one thing we are sure and that is that if everybody waits to see what is going to happen, before spending any money, we will have another prolonged business depression.

This habit of waiting to see what is going to happen is a characteristic of the present generation of American business men. We are timid sons of bold fathers. When our fathers loaded their families and worldly goods into covered wagons and set off acros the eastern mountains, and later the western prairies, they were certain of just one thing and that was that they were going to have a lot of trouble before they made a permanent camp. They knew this but went on just the same and so developed the entire country. We, who take ourselves so seriously, are merely cashing in on the risks taken by the pioneers. Indeed, we are but the flabby and pampered offspring of robust and intrepid parents. As soon as we all realize this we will throw off our timidity and will cease clamoring for more and more protection and will assert our readiness to protect ourselves.

During the last four or five years the writer has been much interested in watching the results of waiting to see what is going to happen next before doing anything. First was the probable overthrow of Cannonism—apparently there was to be a change in the political complexion of the majority in the House of Representatives. We must wait to see what Champ Clark will do! Perhaps the democratic party will get full control at Washington, let us wait and see! Yes, now that they have control, let us wait and see what they are going to do! Now that they have done so and so let us wait and see what the effect will be! And what was the effect? A first class financial depression before the war broke out. Now the point is this, and here we lift our discussion above the plane of politics: the hard times were due mainly to this waiting policy. Business, being inactive, atrophied. A prosperous nation can think itself into hard times just as a well man can think himself into a sick bed.

Now when it comes to going ahead regardless the private business corporation slows down to a canter or balks. There will be more and more of cantering and less and less of balking as the young men of today come into the control of affairs. In the meanwhile our concern is with the municipal corporation.

Short of the end of the world the worst thing we have to fear is the conquest of this country and the overthrow of our present form of government. This is improbable but should it happen our cities would continue to exist and our citizens would continue to pay taxes. We urge cities to go on planning and building improvements for they will be needed in any event.

When the war ends money will be at a premium no longer and the municipal bond will again have a ready sale. Now let our cities plan their improvements, such improvements as they will need in the next few years, and get through the engineering and legal preliminaries to construction. Then, when the war ends, and private business corporations are in the cyclone cellar, let our municipal corporations begin the biggest era of construction we have ever known. This will be a great stimulus and stabilizer to general business.

It is all very well for city officials to babble of business methods in running the city provided the timidity of private business is not aped. A good town which is below its bonding limit is shirking a highly important duty to itself and the country if it is not now planning for the construction of needed improvements at or before the close of the great war. By this means the period of adjustment will be negotiated without panic and with a minimum of disturbance to general business. Seeing all this activity abroad in the land private business will venture out to resume operations at the old stand.

A NOTABLE COUNTY ROAD SYSTEM.

The conception and planning of county systems of roads are becoming frequent. Many counties have improved roads; often they have considerable mileages of such roads. The visualization and planning of improved roads in county systems are comparatively infrequent, however, and it is this rarer exemplification of county road building to which attention is directed here. This exemplification, as said, is becoming frequent. In proof one naturally thinks first of the most advertised county road systems and those of Wayne county, Michigan; Milwaukee county, Wisconsin, and Cuyahoga county, Ohio, come to mind. These systems happen to be constructed of concrete and brick. In Iowa and Georgia and Massachusetts and doubtless other states are equally notable county systems, perhaps of less durable construction, but as systematically conceived and planned as any of brick or concrete. The idea of county road construction in systems is not confined to any type of construction or to any geographical locality.

Among county road systems one of recent inception deserves notice because of its variation from the normal. In most instances the road system policy has grown out of an experiment. In Wayne county, Michigan, for example, some eight years ago concrete roads were planned experimentally. The first success led to extensions and by accretion a system of concrete roads became skeletonized and finally accumulated the flesh and integument of a defined policy of a county system of concrete roads. The variation from this normal example is the road system of Vermillion county, Illinois. In this county by one action a system of 166 miles of improved roads was financed and planned and put under contract for construction. Of these roads about 145 miles will be concrete. On these 166 miles of improved roads is carried about 80 per cent of the highway traffic of the county.

MOTOR TRUCK PROOF ROAD CONSTRUCTION.

In Massachusetts where populous cities are close neighbors and interurban traffic is of comparatively large volume and not much different in character from urban traffic, the motor truck proof road is a visible possibility. This spring when the state road officials made their inspection trip they found "mile after mile of roads destroyed by motor trucks." This is a very serious statement. Massachusetts has good roads more perfectly maintained than have most other states. If its road construction is inadequate to resist motor truck traffic then so are the roads of any state which are not hard paved roads. In summing up the lessons of his inspection trip Chairman William D. Sohier of the Massachusetts Commission says: "There is only one solution—that is the construction of roads of granite or brick pavement." Mr. Sohier will perhaps admit in full statement that other pavement materials than those named are motor truck proof, but the significance of his comment is not in the naming of two motor truck proof road materials so much as in its expressed conviction that a road construction that is proof against destruction by motors is an early necessity in many localities.

THE DAY OF THE SUPERINTENDENT.

Again this year one day of the annual convention of the American Water Works Association will be set aside as Superintendents' Day. The day, according to the prospectus, will be devoted to answering questions proposed in advance, asking questions, exchange of experiences and short papers or talks on practical questions of interest to the water works superintendent.

Bearing in mind that governmental restrictions are irksome to a democratic people we hope the presiding officer, or officers, on Superintendents' Day will maintain an attitude of dignified neutrality and passivity. Let him leave his gavel and parliamentary rule book in his hotel room. What if the discussion runs away from the announced topic? Let it run its natural course and back again. In this way a good time will be had by all. Too much regulation of the discussion will speedily regulate it out of existence.

THE EFFECT OF PRESENT HIGH STEEL PRICES ON FUTURE CONSTRUCTION AND TRADE OPERATIONS.

The effects of the recent increases in the price of steel are indeed far-reaching and varied. In some cases the principal effects are readily apparent almost as soon as a price change is announced, but in others even those at the head of industries using large quantities of steel seem unable to formulate plans for safeguarding these industries.

In building work the increased cost of steel and the uncertainty of delivery have acted to decrease materially the number of office and other large commercial buildings planned and built. These factors have also, in many cases, resulted in a change in design from the steel frame to the reinforced concrete type. In bridge work the present high steel prices have had similar effect. It is possible, however, in such structures to adjust the building program to conform somewhat closely to steel market conditions.

There are, however, certain industries using large quantities of steel which are placed in an embarrassing position by the recent radical price advances. We refer particularly to the machine, implement and vehicle trade. particularly to the machine, implement and vehicle trades. will, in general, not be marketed as finished products until next year—a period of such length as may bring about a complete change in the market. If manufacturers of these products pay the present high prices for raw materials they are assuming great risks, as they can hardly hope to secure correspondingly high prices for their finished products in case of a low market condition at the time they are marketed. If high prices still prevail consumers are likely to delay purchasing, reasoning that prices must soon come down. The National Implement & Vehicle Association has appointed a committee to formulate a policy and to wait upon the mills with a view to arranging for material for the coming manufacturing year upon a more favorable basis than present prices represent. It is the contention of this association that the business of its members is not such as will admit of the extreme variation of steel prices which we are now experiencing.

The condition confronting implement makers, and in lesser degree other consumers of steel, is indeed one which presents good grounds for concern. It is difficult, however, to see just how steel manufacturers can make price concessions to certain industries without causing serious complaint from other interests. We believe it is time for both consumers of steel and steel manufacturers to agree upon fair prices for steel delivered in the future. Prices have now risen to such a point that manufacturers are in a position to make sharp concessions and still have assurance of a fair profit. We believe, further, that construction and trade operations demand such a procedure as a stimulus and safeguard for future business.

EDITORIAL PARAGRAPHS.

An American invented the rock crusher. He was Eli Whitney Blake and was the nephew of Eli Whitney, the inventor of the cotton gin. Blake invented the rock crusher in 1858 and it was first used to crush rock for concrete and next used in 1859 in street work in Hartford, Conn. Excluding perhaps ore crushing these two tasks have been the principal occupations of rock crushers for nearly three score years.

Was the stone crusher or the road roller the more useful invention of road making machinery? Anyway the road roller was invented the same year, 1859, as was the stone crusher and the inventor was Louis Lemoine, a citizen of Bordeaux, France. Lemoine's roller was used first in 1860 in constructing a road in the Bois de Boulogne. England used a road roller in 1866 and in 1868 a machine imported from England was used in America.

Did any one recall that this year of grace is the two hundredth anniversary of the birth of the first of the modern great road builders? Neither did we. However, Tresaguet, who had written a treatise on road building and was building roads in France when Macadam and Telford were in the cradle, was born at Nevers, France, in 1716.

Since it is a common remark that Americans won't spend money for roads, let us note that the first sentence in the Good Roads Year Book for 1916 is: "It seems probable that during 1916 about $300,000,000 will be spent on highways and highway bridges in the United States." Road tax palsy is not general, according to this statement.

According to statistics rather carefully collected by Dean C. H. Benjamin of Purdue University Engineering Schools, "for five years, 1909-14, the line of progress in income of engineers is represented by the equation

$$y = 600 + 170\,x.$$

in which y = salary for any year and x = number of years since graduation."

Justice Newell of Vermont in 1862 laid the foundation of Federal donations in support of state universities. In 1887 the Hatch Agricultural experiment act granted to each state $15,000 per annum for records in agriculture. Nine years later the Adams act increased this $15,000 to $30,000. There is now before Congress a bill introduced by Senator Newlands of Nevada creating an engineering experiment station at each land grant college and appropriating $15,000 a year to each for directing the work.

DETAILS OF CONSTRUCTION PLANT AND METHODS, EASTON-ALLENTOWN CONCRETE ROAD.*

By Jno. T. Gephart, formerly Construction Engineer, Pennsylvania Highway Department.

Grading and Drainage.—For most of its length the new road occupied the route of an old dirt road—clay underlaid with limestone formation. The old grades were choppy and irregular and since the new road was designed with grades of true tangents and vertical curves a large amount of rough grading had to be done. Fills were constructed in layers rolled with a 10-ton roller and cuts were carefully shaped and rolled. Grade stakes were set each 25 ft. and cross-section and grade were formed accurately to plan. When finally completed to shape the subgrade was protected from all traffic.

The topography rendered easy drainage difficult. Nevertheless extraordinary means were taken to ensure superior drainage. Corrugated iron pipe of sufficient sizes were placed wherever necessary to carry the surface water under the road and properly dispose of it, and concrete culverts were built to take care of the small streams. Under drains of 4-in. porous tile, laid on ½x4-in. boards to maintain an even grade were placed along the entire length of the road, parallel with the road between the concrete and the trolley tracks and from 18-in. to 24-in. below the finished subgrade line. All joints were wrapped loosely with a piece of one-ply tar paper with no lap at the bottom. This paper contains very little tar and will allow easy ingress for the water, and is considered more suitable than "bagging" which is generally used. The trenches were back filled with crusher tailings or other stone crushed to a size of 3 in. or over. A similar tile drain was laid through all cuts, outside the concrete on the side opposite the trolley tracks. Lateral under drains were placed wherever the conditions of the subgrade warranted. All underdrains were carried to an outlet so as to properly dispose of the water and keep the subgrade thoroughly dry.

Transportation and Storage of Materials.—The entire length of the highway was paralleled by the tracks of the Lehigh Valley Traction Co.'s electric line, and all cement, aggregates, forms, reinforcement and other materials were hauled by this railway. Sidings were built into two quarries, one at Bethlehem and one at Farmersville half way between Bethlehem and Easton. Also connection was made with a steam railway siding on which all sand and cement were delivered. Hauling was done in one day shift handling only stone and in one night shift handling cement and sand. The stone was dolomite with a French coefficient of wear exceeding 14; the sand came from Lake Hopatcong, New Jersey, and was substantially free from loam and dirt. Special attention was given to the proper distribution of the concrete materials, and rehandling was practically eliminated. The sand and stone cars were dumped at measured distances from the end of the last placed concrete. The cement was stored in portable canvass covered sheds holding 90 sacks each, placed at measured distances along the road, and carried ahead as they were emptied.

Construction Plant.—In addition to the customary small tools required for the construction of a road, the major equipment consisted of two rooter plows; two 10-ton, three-wheel power rollers; two No. 16 Koehring mixers with boom and bucket delivery; two 4-hp. C. H. & E. gasoline pumps; four miles of 2-in. wrought iron pipe; two 100-ton crushing plants, and one small gasoline crusher for drain stone.

Construction Procedure.—After the rough grading was done, the subgrade was finished and rolled while the drains were being placed. The "concrete" crew, the "finishing" crew, and the "curing" crew followed in order, after which came the "trimming up" crew who removed the earth from the finished concrete surface and properly constructed the berms and opened the gutters.

---

*Extracts from a paper read at the Chicago meeting of the American Concrete Institute.

Concrete Mixing.—The concrete consisted of one part Portland cement, two parts sand, and three parts crushed stone. The sand, being dredged, was very clean and graded in size from very fine to pea gravel size. The crushed stone, a dolomite, was of such size as to pass a screen having a 1½-in. circular opening and retained on a screen having a ¼-in. circular opening.

By experimenting and testing, it was proven that the maximum strength of the concrete as proportioned above resulted from being mixed 90 seconds in a batch mixer of approved type, and continued for 17 complete revolutions of the drum for each 60 seconds. Accordingly, this method was followed and each batch was mixed 90 seconds, receiving from 24 to 26 complete revolutions of the drum. Sufficient water was used to produce a plastic concrete, so that when it was deposited, it would settle to a flattened mass but not cause a separation of the mortar from the coarse aggregate when handled. The drum of the mixer was completely emptied before mixing the next batch. No retempering of any batch which had taken its initial set was allowed.

Concreting Procedure.—The concrete roadway was constructed in sections 16 ft. wide, 39 ft. 6 in. long (having transverse joints as described later, between sections) 6 in. thick at the sides and 8 in. thick at the center, thus giving a 2-in. crown from the center to each side of the road.

Each crew consisted of 2 finishers, 2 men handling strike boards, 2 men placing concrete and reinforcement, 1 mixer engineer, 1 fireman, 1 charging man, 2 men on forms, 3 cement men, 8 sand and stone men, 3 men sprinkling and covering the finished concrete.

The concrete was placed between side forms. These forms, which were 6 in. heavy Baker steel forms in 12-ft. lengths, were set true to line and grade and held in place by steel stakes so that the upper edges of the forms conformed to the established grade of the road. All mortar and dirt were removed from forms that had previously been used and the forms were oiled before resetting them.

Immediately prior to placing the concrete, the subgrade was thoroughly wet to assure proper curing of the bottom of the slab, but the water was not allowed to stand in pools. After being mixed, the concrete was deposited rapidly upon the prepared subgrade, in successive batches to a depth of 3½ in. at the sides and 5½ in. at the center for the entire length between the transverse joints; before the concrete could receive its initial set, reinforcement was placed the entire width and length between the transverse joints, and the remaining 2½ in. in depth of concrete was placed. This entire operation was continuous as no intermediate joints were allowed, and in case of a break down of the mixer, the concrete was mixed by hand to complete the section. Transverse joints were placed between sections.

The reinforcing used was No. 25 Kahn Road Mesh in sheets 5 ft. 2 in. wide and from 6 ft. to 10 ft. long. It was laid parallel with the axis of the road, joints staggered, and with a lap of 4 in. crosswise and 12 in. lengthwise. The transverse joints were made by tying two 9-in. x 16-ft. strips of ⅛-in. Elastite to a 9-in. x 16-ft. steel plate, the assembled joints being placed across the pavement perpendicular to the subgrade, at right angles to the center line of the road and 39 ft. 6 in. apart, with the Elastite next the section being finished. Concrete was placed on both sides, that on the Elastite side being stuck off, the strings cut and the plate pulled out by its handles. After the concrete had set 24 hours, the Elastite was trimmed off ½ in. above the finished section of concrete.

After placing the concrete as described, the surface was stuck off with an extra heavy strike board, followed by a lighter one, both of which were moved with a combined longitudinal and crosswise motion working off the side forms. When the strike boards were within two or three feet of the transverse joint, they were lifted to the joint and the pavement stuck by moving them away from the joint. Any excess concrete which accumulated by striking the pavement was removed and any holes left by removing the steel plate used in placing the transverse joints were immediately filled with grout.

Finishing and Curing.—After the concrete had been brought to the established grade and crown with the strike boards, it was finished with wood floats in such a manner as to properly compact it and give a surface free from all inequalities. When floating the concrete, the men worked from a bridge, resting on the side forms, extending over the concrete, but not touching the concrete at any point. The concrete at the transverse joints was floated with a double float, allowing the Elastite to pass through the center of it and thus producing a smooth, even finish on each side of the joint. The edges of the concrete at the sides of the road and at the transverse joints were beveled with steel edgers so as to liminate chipping. A 2-in. radius edger giving a ¾-in. bevel was used at the sides and a 1-in. radius edger giving a 3/16-in. bevel was used at the transverse joints. The floating and edging was not done until the surface of the concrete had a glossy appearance. After the floating had been completed and the concrete sufficiently set, the forms were removed, generally in about 18 hours.

Under a very hot sun, the finished concrete was protected by canvas covering supported by wood frames to prevent the canvas from touching the concrete. The finished surface of the pavement was sprinkled with water as soon as the concrete had set sufficiently to prevent pitting, and was kept wet until a 2-in. earth covering could be placed without damage to the concrete. This earth covering was kept wet for a period of ten days and after fourteen days it was removed and placed on the berms where needed, and all excess disposed of. During this curing period, when the temperature dropped in the daytime to 50° Fahrenheit, the pavement was sprinkled occasionally, but not covered with earth. All traffic was kept off the finished pavement for 28 days.

INCREASING WATER WORKS EFFICIENCY UNDER CITY MANAGER GOVERNMENT.

At the annual convention of the City Managers' Association the various managers reported their experiences and enumerated what they have accomplished. In numerous cases improved water service at decreased cost was reported. This article brings together the reports with reference to the water systems. What follows is quoted:

Dayton, Ohio.—One of the worst things here was our water works situation and we have entirely gone over the old pumps and increased their efficiency about thirty per cent. The mains were too small, being mains which were for a city of thirty thousand inhabitants when laid. We have increased our water supply with additional wells ten millions and have laid new mains and practically rejuvenated all the system and have laid underground 6,500 tons of cast iron pipe this year (1915).

Grove City, Pa.—Some two years ago Grove City had an epidemic of typhoid fever, the result of lack of care in the water supply. Wells had been driven along the creek bank; the casing got out and the creek water got in. We took up the water works trouble and we spent some $30,000 in remodeling the whole system, drilling new wells, moving our pumps, putting up standpipe, new mains, etc.

Grand Haven, Mich.—Some of the people were getting water and there was no record of the water tax; they never paid any water tax. There were two factories there that were using considerably more water than they ever intended to pay for, and after getting these things straightened around, the water plant showed a fairly good earning. We also made some changes in the coal buying.

Iowa Falls, Ia.—Probably one of our best showings has been made in our water works department.

A year ago today we were pumping on an average about 15 hours per day to supply our water patrons who at that time were not on water meters, and our quarterly revenue amounted to about $1,600.

Today we have metered practically all of our consumers, and are pumping only according to daily reports filed with me by our engineers, 7½ hours per day, and our quarterly revenue for the past two quarters has been over $1,800 each quarter. Which shows that we have made a big saving at our pumping station on fuel, water and labor, and are getting $200 more revenue per quarter for half as much pumping as a year ago.

Under our ordinance the property owners have to buy their water meters from us, as we will not sell water except through a meter, and we consider the meter a fixture in the house, or part of the interior plumbing system.

We bought and are buying an $8 meter with connections, reducers, seals, sealing wires and sealers, for $6 in a contract to purchase 400 or more of these meters. We sell this meter and all connections, etc., to the consumers here for the same price we paid for it. This naturally pleases our consumers, as under the old form of government, they only had on about 40 meters, which cost the city $8.60 and they made the consumer pay $10 for it. Our idea is to give our people the advantage of anything that we can buy in this line at the lowest price or actual cost.

Jackson, Mich.—We started a waste water survey that will save about 400,000 gal. per day, started a centralization of the water department, and bought coal on a B. T. U. and ash basis.

Sherman, Texas.—Perhaps, as is usual in most cities, it was found the books were in very poor shape. In the water works a shortage was found of several thousand dollars; an attempt is being made to recover this. Four or five thousand dollars delinquent rents in the water department are now being collected. A cut-off rule is being rigidly enforced.

In the water department we have initiated an inspection of every service in the city and a test of every meter in the city. In this way we hope not only to find the inaccurate and slow meters but to locate leakage not only for our own benefit but for the consumers. We have also discontinued making allowances on account of leakage, making the claim that water is a commodity and there is no more reason for making an allowance for water delivered to the person than anything else although heretofore they had been accustomed to making allowances for that purpose. We are drawing an ordinance which is considerably more rigid than our present ordinance requiring or which will provide for concrete meter boxes and cut-offs and will possibly also make a slight reduction in rate and probably provide for a discount period which we do not now have in our ordinance for payment. We are also proceeding to complete the metering of the town. It is probably about ninety per cent metered and we expect our new ordinance to provide that all churches and schools and all users shall pay for water although at a reduced rate. These are now getting it free. We have two water plants. The steam plant is idle a good part of the day although we maintain a full corps there and maintain steam under the boilers. We are working at plans to consolidate our two plants and will get better efficiency in pumping. I fully expect to save from ten to twenty thousand dollars a year in the operation of our water plant.

St. Augustine, Fla.—We have employed a special water works engineer to come to St. Augustine and make a complete survey and give us a comprehensive survey of the needs for providing an adequate water supply and distribution system, neither the supply or distribution system being full and adequate, not only for domestic service, but for fire protection.

Winnetka, Ill.—The big bone of contention in Winnetka before I arrived there was the water works and electric light plant. It has been run by a superintendent, for the past 18 years, pretty much as he saw fit. He has been gone now since the 1st of July, and I have started in to try to do something. We do a gross business of about $100,000 a year in the light and water department. That was a place where I was more able through my previous training to accomplish things. In starting out, I got rid of deadheads on the payroll by letting men out of the plant which cut down the payroll a little over $500 a month. I next started in on boiler evaporation and was able to bring up my boiler evaporation from about 5 lb. to 6.95, which will mean about $5,000 this year on our coal bill.

Conclusions.—The foregoing excerpts tend to show the value of a trained man in charge of water works operation. The city manager form of government provides one means of attaining this end. The great majority of city managers are engineers. They have improved water service and decreased costs because they are engineers.

SOME TESTS TO DETERMINE THE EFFECTIVE WIDTH OF LARGE CONCRETE BRIDGE SLABS.*

By A. T. Goldbeck, Engineer of Tests, and E. B. Smith, Associate Mechanical Engineer, U. S. Office of Public Roads.

In June, 1912, an investigation was started at the U. S. Office of Public Roads to determine the distribution of stress in reinforced concrete slabs subjected to concentrated loads, and a report on the first six slabs tested was made in June, 1913, before the American Society for Testing Materials. These preliminary specimens were 9 ft. wide with a span of 6 ft., excepting one which was 6 ft. wide with a span of 12 ft.; the effective thickness varied from 3 in. to 6 in. Although these tests were not conclusive they gave valuable results which perhaps had some influence in governing the subsequent design of bridge slabs. In addition, they indicated the desirability of making more complete tests and suggested to others the importance of continuing investigations along similar lines. During the past two years there have been tested three large-size reinforced bridge slabs built on specially constructed equipment, and it is the purpose of this paper to describe briefly these tests.

Object of Tests.—The object in view is to secure data concerning the distribution of stresses in flat reinforced concrete slabs to serve as a basis for reasonable assumption in the design formulas. Whenever the design of a slab is undertaken, some assumption for the width value, b, must be made for substitution in the design formulas used in computing the thickness and the reinforcing. The proper selection of this value has been subject to a great deal of uncertainty, since a wide range of widths have been used in slab designs. The correct design of a slab involves the selection of such a width that its resisting moment (assuming that the stress is uniformly distributed) will be the same as the resisting moment of the whole slab under actual stress conditions. To simplify this statement it needs only to be remembered that resisting moment is a direct function of the fibre stresses or of the fiber deformations. Therefore, the width to be selected should be such that the total maximum fiber stress uniformly distributed will be the same as that of the whole slab whose maximum fiber stress is not uniformly distributed from the center of the slab to the two free edges. This width when so selected is known as the effective width; and its value should be based upon experimental data, from which it may be obtained by dividing the maximum fiber stress into the summation of the maximum fiber stresses along the center line parallel to the supports.

A value for the effective width may be obtained from the fiber deformations of the concrete, and another value from the deformations of the reinforcing steel. A few examples of the difference in these values are shown by the curves of Figs. 3 (a) and 3 (b). It may be seen that the effective width values obtained from the concrete deformations are the smaller, and since there is a difference in the values obtained by these methods, it is obviously proper that the method giving the most conservative value for the effective width is the one which should be used. Thus, if the stresses in the steel showed a more critical change than in the concrete at the center of the slab, or at the load point, then we should be justified in basing our evaluation on the steel stresses or deformations. This, however, does not seem to be the case, as shown in Figs. 3 (a) and 3 (b); it may be seen that the local effect of the load is more pronounced in the concrete than in the steel.

---

*Paper before Convention of American Concrete Institute, Chicago, Feb. 14-17, 1916.

Test Data and Results.—Each of the three slabs herein described was made of 1:2:4 gravel concrete, machine mixed, and each was reinforced with 0.75 per cent of plain square steel bars with no transverse reinforcing. The slabs were 32 ft. wide, of 16 ft. clear span, with a 10-in. bearing width on each support.

The forms were removed from the slabs at the end of two weeks, and each slab was cured in air under approximately the same conditions, within a building constructed especially for housing these tests; the slabs were sprinkled once each day until the forms were removed. Tests were begun at the age of about 26 days and were continued periodically until the time of breaking. Slab No. 835 was broken at the age of about 6 months; slab No. 930 at about 5 months; and slab No. 934 at 3 months. The breaking loads are given in Table I.

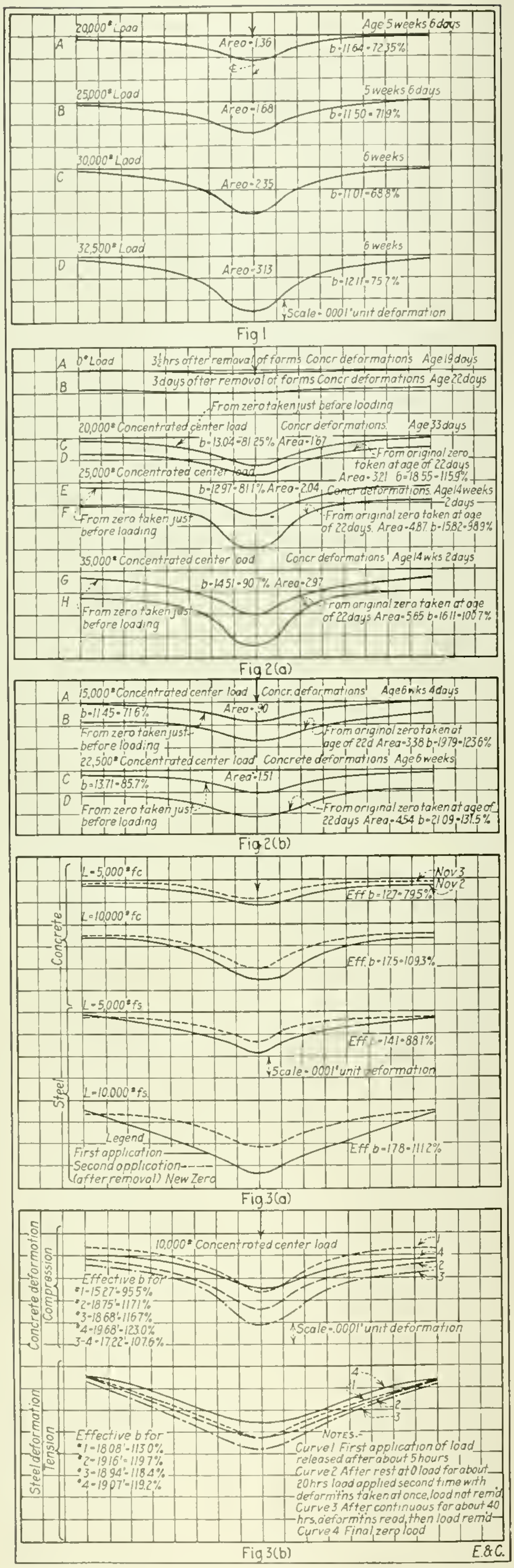
TABLE 1.—DIMENSIONAL DATA ON SLABS.

Serial No.	Thickness. Total.	Effective.	Reinforcing Spacing, in.	Size, in.	Per cent.	Modulus of elasticity.	Breaking load, lb.
835	12	10½	¾	10.5	0.75	2,900,000	119,000
930	10	8½	¾	8.87	0.75	4,000,000	80,000
934	7	6	½	5.56	0.75	3,000,000	40,000

The deformation values for each slab and for the different load values are shown graphically in Figs. 1 to 3, inclusive. Each curve is plotted from the deformation values measured perpendicular to the supports and spaced along the center line parallel to the supports. It will be noted that the general shape of the curves for all loads is the same for the concrete and the steel. The local effect of the load is also shown very clearly.

A series of deflection curves for the last slab tested (No. 934, 6-in. effective thickness) is shown in Figs. 4 (a) and 4 (b). The maximum deflection for the working load was 0.3 in. at the center.

Discussion of Results of Tests.—One of the important facts which these tests have brought out, and which this paper seeks to impress upon concrete engineers, is that the time element is a very large and important factor in determining stress values and their distribution from the fiber deformations. Nearly all materials of construction with which the engineer has to deal will yield an approximately constant relation, independent of the time, between the load and its accompanying deformation within the limit of elasticity. This is not true in the case of concrete, which exhibits a marked flow or molecular adjustment under working stresses extending over time periods of several weeks. During the tests of one of the slabs in August, 1914, this



DEFORMATION CURVES FOR REINFORCED CONCRETE SLABS NOS. 835, 930 AND 934 FOR CONCENTRATED LOAD AT CENTER; ALL SLABS 32 FT. WIDE BY 16 FT. CLEAR SPAN.

Fig. 1—Slab No. 835; Effective Thickness 10.5 In.; Center Load Varying From 20,000 to 32,500 Lb. Fig. 2—Slab No. 930; Effective Thickness 8.5 In.; Center Loads Varying as Shown. Fig. 3—Slab No. 934; Effective Thickness 6 In.; Center Loads Varying as Shown.

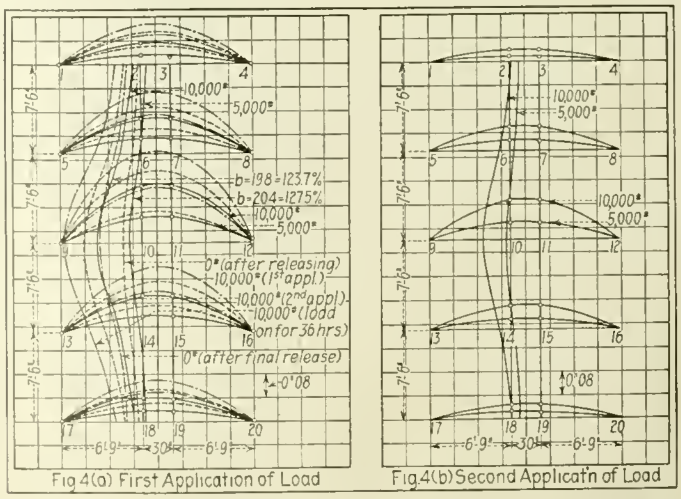


Fig. 4—Deflection Curves for Reinforced Concrete Slab No. 934 for First and Second Applications of Loads as Shown; Slab 32 Ft. Wide by 16 Ft. Clear Span by 6 In. Effective Depth.

TABLE II.—EFFECTIVE WIDTHS FOR CONCRETE SLAB OF 16-FT. SPAN AND 32-FT. WIDTH.

Center load, lb.	Slab No. 835, 10½ in. effective thickness.	Slab No. 930, 8½ in. effective thickness.	Slab No. 934, 6 in. effective thickness.
15,000		11.4 ft.; 71.6 per cent of span	12.7 ft.; 79.5 per cent of span
20,000	11.6 ft.; 72.3 per cent of span	13.0 ft.; 81.2 per cent of span	17.5 ft.; 109.3 per cent of span
25,000	11.5 ft.; 71.9 per cent of span	12.9 ft.; 81.1 per cent of span	
32,500	12.1 ft.; 75.7 per cent of span		
35,000		14.5 ft.; 90.7 per cent of span	
Safe load	12.8 ft.; 75.7 per cent of span	12.9 ft.; 81.1 per cent of span	17.5 ft.; 109.3 per cent of span

phenomenon was first discovered, and a series of experiments was begun to obtain data regarding the flow of concrete. Since it is not the object of this paper to discuss the facts or the theory of this phenomenon, the following statement will be sufficient for the present purpose:

When concrete is subjected to a compressive fiber stress of 700 lb. the immediate fiber deformation is only about 50 per cent of what it will be if the stress is maintained for three weeks. Within 24 hours after the application of the load the deformation has increased an additional 20 per cent; during the first hour the deformation may show a change of 5 per cent or more. Furthermore, the recovery of the deformations, after the removal of the load, is slow and not complete.

The fact is mentioned here to show the importance of taking all the deformation readings at approximately the same time after the load is applied, and in each case a new set of deformation readings under zero load must be taken just before each load application.

The effect of time on the value of the deformations is shown in Figs. 2 (a) and 3 (b). For instance, it may be noted by reference to Fig. 2 (a), curves E and F, that there is a deformation change of about 100 per cent at the center of the slab and nearly 400 per cent at the edges, between the values obtained from a new set of zero readings, taken just before the application of the load, and those obtained from an earlier zero reading taken a few weeks before, with the application and removal of several loads intervening. Also, it should be noted that the value of the effective width is increased nearly 22 per cent. The direct effect of this time factor is shown in Fig. 3 (b), curves 2 and 3 (concrete deformations); here the load was sustained for 48 hours, and the center deformation increased about 20 per cent.

Many other interesting time and set effects may be observed by a detailed study of these curves, but the author's purpose is here accomplished by emphasizing that such tests, and in fact all tests for stress and deformation values in concrete, must be conducted only with a full realization of the importance of the time factor. The immediate fiber deformation is the value which should be used, and not the value obtained after a long-time suspension of the load, nor that which contains the effect of several applications and removals of loads.

The determination of the effective width value for use in the design of flat slabs supported at two edges is attended by so many variables that, from the information at hand, a final and definite formula for its determination cannot be given. Its value, however, is affected by the span, the total width, the thickness, the load on the slab. the distribution of the loads, and probably by special forms of reinforcing. The thickness and the load with its distribution, are the only variables that have been considered in the tests thus far, and the values for the effective widths are collected in Table II.

From these values it may be noted that there is a general tendency for the effective width to increase slightly with the increase of load. Also the effective width seems to vary inversely as the thickness of the slab.

In the light of the information available at the present time, we should be safe in using a value for the effective width equal to 0.7 of the span. This will probably result in the design of a somewhat thinner slab than is usual, but the fiber stress values and the large ultimate breaking loads of these slabs are an indication of the safety of such designs.

This series of experiments has not been completed, but it is being continued with the hope of arriving at a definite formula for determining the value of the effective width as influenced by all of the important variables.

ARTIFICIAL FOUNDATIONS FOR PAVEMENTS.*

By W. W. Crosby, Consulting Engineer, Baltimore, Md.

Under the head of artificial foundations will be included for convenience all layers of foreign material not naturally found in place and specifically provided for the purpose of interposing a layer of some sort between the natural material and the pavement surfacing. Consequently under this head will come layers of sand, gravel or similar material, macadam old or new, paving old or new, as well as the more common exposition of the term—i. e., the concrete slab.

A layer of sand or gravel as an artificial foundation for the pavement is sometimes used to good advantage on subgrades whose supporting power is relatively weak, under such conditions as may be expected to prevail around it, and largely for the purpose of distributing through the medium of a cheaply installed layer, the stresses coming down through this layer from the pavement, so that the strains on the foundation will be within what might be called the "elastic limits" of the latter. Sometimes, the further advantages of such a layer are that they assist in providing drainage, and in increasing the stability of the sub-grade in places. For instance, such a layer may be valuable in preventing the serious effects of frost action otherwise taking place in the spring. Again with sub-grades of clayey material, such a layer of sand or similar fine material, will prevent the working of the subgrade material up into the somewhat porous bottom layer of the macadam to the detriment of the latter. Again, economy may dictate the use of a layer of considerable thickness, say two feet, of sand for the foundation of a pavement where traffic conditions will be relatively light and yet an insufficient sub-grade naturally exists locally.

Properly graded gravel with sufficient sand in it to reduce the voids to a minimum will prove an even stronger artificial foundation than the sand layer above referred to, as there will be less tendency toward displacement under traffic. In the same way, macadam may be superior to the gravel layer and a thinner foundation of macadam may equal or be superior to a much thicker layer of the best available gravel. Well compacted macadam is high in its supporting powers and in its stability in place. The difficulties of using it as an artificial foundation are those always found with materials containing a large percentage of coarse particles—i. e., it is difficult to get its surface sufficiently even so that the surfacing shall be sufficiently smooth, and at the same time have the requisite degree of uniformity in thickness. Without going too much into the question of surfacing, the speaker wishes to point out the necessity, for the sake of evenness in wear, of uniformity in thickness for the surfacing layer of a pavement, whether the latter be sheet asphalt, wood block. brick or stone block. It is true that the blocks are now generally made with a reasonable degree of uniformity in this respect, but if the bedding material on which they are placed be, as is frequently the case, sand, it must be considered as a part of the surfacing layer. The necessity for this bedding layer to be of reasonable uniformity in thickness is now generally recognized and a general demand exists rationally for a high degree of smoothness and evenness in the surface of the foundation. This demand will exist and even become more severe so long as a layer of material quite different from either the foundation or the surfacing material itself shall continue to be placed between the two.

Many brick pavements have been laid using the old macadam surfacing as a foundation. The failures of most of them have been directly connected with the unevenness of the sand layer required for the purpose of evening up the surface of the macadam and furnishing a bed in which to set the brick. Where newly laid macadam was attempted, to provide for a foundation for such pavements, some of the failures have been attributable to insufficient consolidation of the macadam prior to the brick laying and to subsequent shifting of the sand layer between the macadam and the brick, which shifting was caused or intensified by the passage of the sand into the interstices of the insufficiently compacted macadam foundation, as well as to the lack of evenness for the surface of the macadam and lack of uniformity in the thickness of the sand layer.

---

*Extract from a paper before the Canadian and International Road Congress.

Old pavements have frequently been used as foundations for new pavements and in some cases an artificial foundation in the shape of a stone pavement has been provided for the new pavement. Such foundations are of considerable antiquity. The Telford pavement as a base for a macadam surfacing is a well known instance. There are many cases in cities of this country where the streets were originally paved more or less roughly with stone blocks, or so-called cobble stones, and these old pavements used, with or without relaying, as foundations for different kinds of pavement surfacings. Various degrees of satisfaction have resulted. Properly laid, the supporting power and stability of such foundations is relatively high and in many cases under the local conditions their use has been economical. On the other hand, in some cases, the development of traffic conditions has resulted in such severe strains on these foundations that they have failed, and have had to be replaced by the more substantial concrete slab. Probably most of the failures of these pavements as foundations have come through the lack of evenness of surface obtainable on them, and a consequent lack of uniformity in the thickness of the pavement surfacing.

Apparently the highest type of artificial foundation is the concrete slab. The power of such a foundation to distribute widely stresses coming through it is very high, so high in fact that it will often carry stresses like a beam. Little has actually been determined as to its distributing power and as to its abilities in pavement foundations to carry indefinitely these beam-like strains. There is great need for investigation on these points. The cement concrete slab, however, has proven its ability to aid weak sub-grades to carry satisfactorily continuous heavy traffic; to aid good sub-grades to support the heaviest traffic; and, within limits, to insure permanency for these effects or results. "Within limits" is used in this statement because of the rather recently developed agreement among at least engineers advanced in the study of the matter, to the effect that cement concrete slabs used as pavement foundations are not the rigid masses they were commonly supposed to be, nor is their elastic limit in any cases coincident by any means with their ultimate strength. On the contrary, they have a limited amount of resiliency or elasticity, and they have what is perhaps fully as important, the ability to become permanently deformed. That is, the cement concrete under continuously repeated stresses flows and the slab takes a different position from that which it formerly occupied. This theory explains the deformation of the surface of some pavements which has occurred in numerous cases, and which cannot be explained by any shifting of the pavement surfacing or of any intermediate sand layer. In such cases, the surface of the concrete foundation is found to be deformed and yet no deterioration of the concrete itself is evident.

Admitting this to be true shows again the necessity of proper consideration of the sub-grade even when it is to be reinforced or supplemented by a concrete layer above it. Too often the practice has been to consider no care necessary in the selection or preparation of the sub-grade where a concrete slab was to be interposed between it and the pavement surface. The contrary should be the real practice, and not only should the decision as to the use of the concrete slab be based on careful consideration of the possibilities with the natural material of the sub-grade, or of other materials brought in for its improvement, but also, when the concrete slab shall be decided upon for use, careful consideration of the possibilities of the natural material for the sub-grade, and even of other materials brought in for its reinforcement, should be had, so that the utmost use of the concrete slab may be developed, as well as economy had in its introduction.

The standard concrete pavement foundation in America is 6 in. in thickness. A greater thickness has been advocated as desirable and even necessary under certain extreme traffic conditions. It is a fact that the pavement on a 6-in. slab seems to have given way under such traffic conditions in certain cases, but it is equally the fact that even in these cases the fracture of the slab or the actual failure of the slab itself as such has seldom been found to take place. What did occur was the subsidence or deformation of the slab without fracture and without destruction and this deformation appears to have been permitted by a failure of the supporting foundation. It would seem to the writer that a remedy such as preparing and providing better sub-grades should be considered in these cases along with the provision of a thicker slab, and that the decision might be for one or the other according to the demands of economy in the case.

On the other hand, the necessity for a minimum thickness of 6 in. to the concrete slab in all cases may be questioned, and why even 3 in. of good concrete would not answer the purpose under many local conditions and where proper regard is to be shown the preparation of the sub-grade and the provision of a permanent and fairly substantial natural foundation, is not apparent.

BROAD STATE CONTROL OF MARYLAND WATER SUPPLIES.*

By Robert B. Morse, Chief Engineer, and Harry R. Hall, Assistant Chief Engineer, Maryland State Department of Health.

Maryland, through its State Board of Health, has had, since 1914, strict supervisory control over the design, construction and operation of water systems. No material extensions of, nor alterations in, existing systems can be legally made, nor can new supplies be installed, unless complete plans and specifications covering the proposed work are submitted to the State Board of Health for approval and a written permit is granted by that body. Moreover, when deemed necessary for the public health or welfare, the State Board of Health may require existing water systems extended or altered, and it is empowered to compel the installation of public supplies in communities not served. It is the duty of the corporate officers to raise the funds necessary for carrying out the work required, and they may do this, if they wish, by issuing bonds, without special legislative enactment, and without a referendum vote.

Broad as is the control of the state over the design and construction of water supplies, it is no more liberal than is its authority over the operation of existing systems, insofar as the public health is affected. If the State Board of Health finds that any water plant is not properly operated, it may require a change of method, and may, when necessary, force the employment of competent attendants, it even being enabled to attain this end by appointing attendants of its own selection, at the cost of the municipality or water company owning the plant. Possible arbitrary action, however, is precluded by a provision in the law allowing appeal to the local county court, before which the board would have to prove the reasonableness of its act.

An effort has been made by the State Board of Health to use its power in a judicious manner and not to attempt coercive measures where proper improvements could be brought about in other ways. It has not yet been necessary to invoke the full extent of its legal power, and in no case has the board been compelled to appoint operating attendants for water supplies which have been improperly cared for, although in some instances this might well have been done.

---

*From paper before New England Water Works Association.

MAKING UP A FOREMAN'S PLAT, WATER DEPARTMENT, WASHINGTON, D. C.

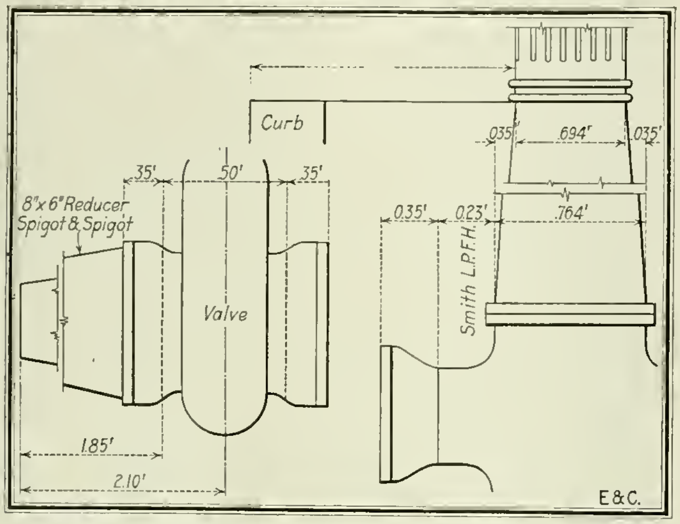
The procedure in making up a foreman's plat in the water department of Washington, D. C., is clearly indicated by the following set of descriptive instructions:

1. Foreman's plats are made up, so far as possible, on white Bristol board cards of first-class quality, 8x10 in. in size. Where a job is too large for one card, use two. Should the job be too large for two cards, make it up on white unsensitized blueprint cloth.

2. From Mr. Heins' (chief draftsman)' "In Box" get one of the jobs assigned to you. Take the job time card from your future work hook and opposite your name mark the date and time, and on the "Location" line write the location of the job.

3. Get a plat card from the drawer of Mr. Heins' table, or if the job is large enough to require that it be made on white cloth, this will be found in the material case in room 310.

4. Plat-boards are used, so far as possible, in the making up of plats. The body of the board, 9x11 in., is made of ½-in. white pine, the upper left-hand corner forming a true right angle. Hard wood strips ½-in. in thickness are fastened to the ends and upper side, the left-hand and upper side strips being ⅛ in. higher than the surface of the board. By the use of this board no thumb tacks are required, and only one triangle is required for a great deal of the work.



Measurements Recorded on Foreman's Fire Hydrant Plats, Water Department, Washington, D. C.

5. The short sides of the cards are north and south, the long sides east and west. The job number is placed in the upper left-hand corner. Should two cards be required, mark to right of job number "Card 1," "Card 2."

Where more than one plat is required under one job number, sub-numbers are given. The sub-number should be placed in the upper right-hand corner.

The plat stamp is placed in the lower right-hand corner. Be careful not to place stamp too near edges of card, in order that there may be sufficient room for the lettering, initials, etc.

The bill of material is placed in the lower left-hand corner, and the north point, so far as possible, in the upper right-hand corner.

When the plat is made on white cloth a bill of material must be made up on a regular plat card, giving job number on the upper left-hand corner, map numbers and location in upper right-hand corner and plat stamp properly filled out, in lower right-hand corner.

All plats, excepting those showing the laying of mains, must have a title describing briefly the nature of the job. This title is placed in the middle and near the upper edge of the card.

When working from engineer's notes made upon double sheets, do not turn the notes inside out and crease them. Lay the sheet out flat on the table, and when through with it fold back as originally found.

Block numbers need not be shown on plats unless lots are shown or in case of an alley main running off a minor street.

6. Scales: Select a scale for the plat, which will enable you to show all the dimensions clearly. For small jobs, such as new or replaced fire hydrants, valves, etc., a scale of 1 in. = 20 ft. is generally used. In some cases where it can be used to advantage a scale of 1 in. = 10 ft. is used. In other cases, and in making up plats of new mains laid, a much smaller scale is used, and all parts, the dimensions of which cannot be shown clearly, are detailed on a much larger scale.

7. Details: For details, use a scale just sufficiently large to show all the dimensions clearly. The detail must be projected from the drawing, and so placed that it will be easy to indicate the point detailed. Do not take in too much in your detail. Only show the part that actually needs detailing. When the detail is completed it is inclosed with a fine line, from which a line is extended ending in an arrow point at the point detailed. Always show the scale of the detail.

8. Measurements: When an over-all measurement ends with a new bell, substract 0.35 ft. from length of main. When it ends in an old bell, add 0.35 ft. When a measurement is to the center of an old valve, add 0.25 ft.

The distance covered by a new valve must be included in the length of the new main.

In giving the amount of main laid, the over-all distance must be given, and nothing deducted for fittings. The amount of fittings must be added up and written in pencil near the lower edge of plat.

The over-all measurement for 4, 6 and 8-in. divide valves is taken as 0.5 ft.

For 3 or 4 stem valves, take 0.5 ft. each way from center of valve.

A reducer is counted as main of the larger dimension.

The measurements used in fire hydrant plats is illustrated herewith.

The foregoing instructions are signed by C. P. Heins, Chief Draftsman. Mr. J. S. Garland is Superintendent of the Water Department.

COST OF ENGINEERING SUPERVISION IN ROAD WORK.*

By Lamar Cobb, State Engineer, Phoenix, Arizona.

Based on inquiries addressed to state road officials the following data were amassed relating to cost of engineering supervision:

Alabama.—Bulletin No. 4 shows that in twenty counties the percentage for plans and surveys was about 3 per cent and for engineering during construction the percentage was about 5.9 per cent of the total cost of construction. The cost of all engineering work would be, therefore, about 8.9 per cent of the total cost of construction. The administrative charges are not shown.

Arizona.—The percentage for plans and surveys is 4.6 per cent and for engineering and inspection during construction 4 per cent, or total engineering and inspection, 8.6 per cent, based on total cost of construction and engineering. The cost of executive and administration is 3.6 per cent, making grand total overhead expenses 12.2 per cent.

Connecticut.—The percentage for surveys, plans, etc., is about 0.88 of 1 per cent, and for engineering during construction about 4.94 per cent of the total cost. The cost of the work done by the state highway commission in connection with roads and bridges amounts to about 0.7 of 1 per cent of the total expenditures of the various counties on roads and bridges.

Kansas.—On bridge construction the percentage for plans, estimates, specifications, etc., average about 1 per cent, and for engineering supervision and inspection from 2 per cent to 5 per cent of the contract price, making the cost of all the engineering and supervision about 4.5 per cent of the total cost of the work. On road construction the percentage for all engineering and supervision on macadam and concrete roads is about 8 per cent of the contract price.

Maine.—The percentage for surveys, plans, specifications, etc., is about 2.27 per cent, and for inspection and engineering supervision about 3.58 per cent of the total cost of the work. On small work it is estimated this percentage will be as high as 10 or 11 per cent.

Maryland.—On the state aid roads completed between June 1, 1910, and December 31, 1913, the percentage for survey, plans, estimates, etc., was about 0.5 of 1 per cent, and for engineering during construction about 3.2 per cent of the total cost of the work. The percentage for other engineering and administration was about 4.7 per cent, making the cost of all engineering and administration about 8.4 per cent of the total cost of the work.

Massachusetts.—The percentage for surveys, plans, etc., is about 1.9 per cent, and for engineering during construction about 4.5 per cent of the total cost of the work. The cost of administration is about 1.2 per cent, making the cost of all engineering and administration about 7.6 per cent of the total cost of the work.

Minnesota.—For the year 1914 all the expenditures for engineering and supervision amounted to about 5½ per cent of the total cost of the work done. Mr. Geo. W. Cooley, state engineer, states that he believes this amount to be smaller than is desirable. He believes very nearly 10 per cent is necessary for actual close supervision.

New Jersey.—On twenty pieces of work the average percentage for surveys, plans, etc., was 1.8 per cent and for other engineering was 4.1 per cent, making the cost of all engineering about 5.9 per cent of the total cost of the work. The cost of administration was not given.

---

*Extract from a paper before the Pan American Road Congress.

New Mexico.—On bridge construction the expenditures for engineering and inspection amount to about 3 per cent of the total cost. On road construction the expenditure for engineering and inspection amount to about 5.2 per cent, and for administration and office engineering about 7.42 per cent of the total cost of the work. The cost of all engineering and administration on road construction would be about 12.62 per cent of the total cost of the work.

New York.—The report of the Commissioner of Highways for 1914 shows about 11.2 per cent of the total expenditures to be for engineering and inspection and about 3 per cent for administration, making the cost of all engineering and administration about 14.2 per cent of the total expenditures.

North Carolina.—The information available covers a few roads only and shows that about 4.06 per cent of the total cost of the work was expended for engineering and inspection. The administration charges appear to be in addition to the above.

Ohio.—Bulletin No. 22 shows that about 5.71 per cent of the total cost of road construction was expended for engineering. The cost of administration appears to be in addition to the above.

Oregon.—Upon various pieces of work reported for year ending November 30, 1914, the cost of the engineering varies from about 4 per cent to about 9.4 per cent of the total cost of the work. The cost of administration is not shown separately.

Pennsylvania.—The report for the year 1913-14 shows the expenditures for engineering and inspection on completed contracts to be about 5.6 per cent of the total cost and for administration about 1.4 per cent, making the cost of all engineering and administration about 7 per cent of the total cost of the work.

Rhode Island.—On paved roads the expenditures for surveys, plans, specifications, etc., amount to about 2 per cent and for engineering and inspection about 2 per cent of the total cost of the work. The percentage for administration amounts to about 5 per cent, making the cost of all engineering and administration about 9 per cent of the cost of the work.

Virginia.—The expenditures for all engineering and inspection amounted to about 5 per cent of the total cost of construction in 1914. The commissioner states, however, that in his opinion a larger percentage would result in a substantial saving to the state.

Wisconsin.—In 1914 all overhead charges, including engineering and administration were slightly under 5 per cent on road construction. The inspector on the work is, however, charged to construction. The cost of preparing plans, etc., for bridge construction was about 2.8 per cent of the cost of construction.

THE ARRANGEMENT AND REQUIREMENTS OF ELEVATORS IN OFFICE BUILDINGS.*

The paramount requisite for the success of a high building is good elevator service. The following is a discussion of the fundamental factors entering into the solution of the elevator problem in office buildings.

Number of Elevators Required.—Experience has evolved two theoretical methods for determining the number of elevators required for any building, which in practical use have given very satisfactory results. The two methods are:

1. Allow one elevator for every 20,000 to 30,000 sq. ft. of renting space above the first floor.
2. Allow 1 sq. ft. of elevator floor area to each 1,200 sq. ft. of renting area above the first floor.

The first method is perhaps the better one, as the number of cars is of more vital importance than the size of the cars; for it can be easily seen that two cars of 30 sq. ft. area each would give better service than one car with a floor area of 60 sq. ft. The greatest consideration in determining the number of elevators is to have enough cars, so that there will always be one at the ground floor ready to start on the upward trip. The greater the number of cars the smaller may be the ratio of the cars to the renting area, as with a large number of cars the problem of always having a car at the ground floor solves itself. Where there are less than six cars the ratio should not fall below the maximum of 30,000 sq. ft., while if there are ten cars or over the minimum of 20,000 sq. ft. may be safely used. The character of the tenancy of the building must be considered, for a building occupied by doctors, studios or retail shops, all having many callers, will require more elevator service than a building occupied by big industrial companies having but few callers.

Location of Elevators.—The general location of the elevators must be determined in relation to the typical floor plan rather than to the first floor plan, for here any extravagant use of floor space is multiplied by the number of floors. The elevators must be easy of access to all parts of the typical floors, a central location being the most desirable. However, in many cases a dark corner or the blank party wall is the wisest location, as these spaces are of little value for renting purposes. The bank of cars should be arranged so as not to divide the typical floor, because the renting area should be in one open space in order that it may be rented to a single tenant. This is easily accomplished when the elevators are on the blank party wall, but when they are centrally located greater care is required to prevent them from dividing the floor area into two parts which could not be used advantageously by a single tenant. In case both express and local services are employed the local cars should be stopped at an intermediate floor and space over them on the upper floors rented.

Freight Elevators.—There are three methods for the arrangement of freight elevators in office buildings. The choice of a method depends upon the amount of freight that must be handled and the character and the promptness of the service required. These methods are:

1. The most common and the most satisfactory method is that of having a freight receiving room and one or more freight elevators at the rear of the building, with direct access to the alley or receiving court at the first floor.

2. A more economical method, but a fairly satisfactory one, is that of installing a separate freight elevator at the rear of the building, but without a receiving room at any of the floors. In this case the elevator opens directly upon the alley as well as into the public corridor on the typical floors.

3. A third and the more economical method is that of using one elevator in common for passengers and for the delivery of freight, which means that no freight can be delivered during the rush hours, when the car must be used for passengers. Where this system is used it is usually necessary to install a lift to carry freight from the alley to the basement, where it can be sorted and stored until such an hour as it is possible to deliver it to the upper floors. This type of installation necessitates the delivery of small packages which cannot be delayed, as well as the carrying of the building employes in the passenger cars. Many tenants object to entering elevators with delivery men and building employes, so before this system is adopted the interests of the tenants and the character of the service to be given them must be carefully considered.

Relation of Elevators to Lobby.—As already mentioned, the location of the elevators will be largely determined by the arrangement of the typical floor, but their relation to the ground floor cannot be disregarded. The paramount requirement is that the elevators be in direct view of a person entering the building, and they should be as near the entrance as their disposition on the typical floor will allow. The directory board should be so located that visitors to the building will pass it on their way to the elevators, but so situated that those standing in front of it will not block the free passage of others. The mail box and the cigar stand must also be so placed that people loitering at either will not interfere with the free passage to and from the elevators. The entrance to the main stairs should be as near the building entrance as possible and always nearer than the elevators, as any callers to the second floor will walk up and they should not be forced to mingle with or block those passing to and from the elevators. If in any large building there are two entrances there should not be a bank of elevators at each entrance unless the building is large enough to warrant each bank having at least six cars.

---

*From a paper by Cecil F. Baker in The Architectural Record.

Arrangement Within the Bank.—The manner of arranging the elevators within the bank may be classed under four schemes, all of which may be varied as occasion demands.

1. The most common method is that of placing the cars in a line perpendicular to the street. Experience tends to show that this arrangement, when more than seven cars are required, is not entirely satisfactory, as with more than this number of cars the distance from one end of the bank to the other is so great that a person missing a car at one end is forced to walk too far to catch a car at the other end.

2. Another arrangement is that of placing the cars parallel with the street. For a small, shallow building this method is very satisfactory, but where a large number of cars are required it is subject to the same criticism as the previous scheme, although if the entrance corridor meets the elevator lobby opposite the center of the bank this objection is overcome.

3. The fan-shaped bank of cars gives excellent results, but is extravagant of floor space. In perhaps no other scheme are the cars in so direct a view of a person entering the building or so equally distant from the entrance.

4. The U-shaped plan has from the point of service as great advantages as the fan plan, while it has much greater advantages from the point of economy of space and the possibilities which it offers for a good architectural treatment of the lobby. To the writer this seems to be the ideal arrangement for a bank of elevators. Upon entering the lobby a person can see every signal light and upon reaching the open side of the U he is almost equally distant from every car, so in case of missing the one for which he had started he has but a few steps to take to reach any other car.

Design of Grilles and Fronts.—The design of elevator fronts is largely a matter of architectural design, but the various combinations of materials which may be employed in executing the design to some extent necessitates certain practical considerations as effecting the efficiency of the service. Generally speaking these treatments may be classed under three heads.

1. The first is that in which the entire wall surfaces are covered with marble, tile or terra cotta. When these materials are employed the danger to be avoided is that deep door reveals or heavy pilasters do not obscure the elevator doors, signal lights and indicators from the view of a person entering the lobby. In treatment of this sort the signal lights and indicators should always be outside of the door reveal. When the bank of elevators is parallel to the street this danger is not so great.

2. The next method is a combination of materials already mentioned, with more or less metal grille, in which case care must again be taken that neither pilasters nor columns project too much. The writer has known of several instances where it has been necessary, because of the projection of heavy pilasters, to reconstruct and to extend the signal light brackets after the lobby has been in use for some months. The same defect and the deepness of the door reveals were vital factors among those which necessitated the entire reconstruction of one lobby.

3. An all grille front is the most desirable, as the contrast of the grille with other parts of the lobby aids in attracting attention to the elevators and a grille lends itself readily to a very flat treatment, thus obviating the dangers of protruding projections of the wall surfaces.

Experience has shown that the door widths should vary but little from 4 ft.; the doors should always be two-fold and, if possible, the two folds should slide in opposite directions, both of these items being of more than temporary moment in the speed and safety with which the doors can be operated.

The size of the cars will, of course, depend upon the conditions of each particular problem, but in few cases should a car have a floor area under 30 sq. ft. and seldom should it be over 50 sq. ft. The cars should always be wider than they are deep in order to avoid delay and danger of accident occasioned by passengers passing one another within the car.

Accessories.—It is becoming quite a common practice to install wire glass behind elevator grilles. This does not detract from the appearance of a good grille and has two distinct advantages. The shutting off of the elevator shafts does away with disagreeable drafts which are so common in the corridors of large buildings with open elevator shafts, and the wire glass will often lower the insurance rate. The glass should be a clear wire plate, for an obscure glass is undesirable as the operator of the elevator should be able to see out from his car at all floors.

The signal lights and indicators should be placed immediately over each door and at a height not greater than 9 ft. The numerals and hands of the indicator should contrast in color with the dial, for as elegant as a polished bronze indicator may be it is of little use, particularly when reflections of light strike its polished surfaces. The simpler the signal lights the better; nothing can be more satisfactory than a sperical globe of not less than 7 in. in diameter with different colored lights in the upper and lower halves, one for "down" and one for "up."

The call-back bell should be placed at the point where the elevator starter will be stationed, and the night bell should be conspicuously located at the end of the elevator bank which is nearest to the entrance of the lobby.

Floors in Cars and Before Doors.—The problem of floors in the elevators as well as in front of the doors in the lobby at each floor is important for several reasons. A material selected for these floors must be very durable. It must be non-slipping and must present a surface which can be easily cleaned and which will look well when clean. To fulfill these requirements there seem to be but three materials which can be used satisfactorily: loose rubber mats, rubber tile, or cork tile. Loose rubber mats, although cheaper to install than either of the other materials, are neither so economical nor satisfactory in the long run. Rubber tile and cork tile wear well, are easily cleaned, and require no finished floor under them, while their non-slipping qualities are good.

Regardless of which one of these materials is used, a brass angle should be installed at the juncture between it and the marble or the tile floor. The non-slipping surface should run the full length of the elevator fronts, and not just in front of the doors, as serious accidents have occurred to people slipping in making a short turn onto a marble or tile floor upon leaving the elevator.

UNIFORMITY REQUIRED IN PAVEMENT FOUNDATIONS.*

By W. W. Crosby, Consulting Engineer, Baltimore, Md.

The desirability for uniformity in the foundation for a pavement is going to be more generally recognized. It is important because otherwise uniform wear of the surface is not likely to take place, and uniform wear of the surface, even if somewhat more rapid, is more desirable and less expensive to counteract than light or slow wear in some spots and heavy or rapid wear in adjacent areas. This latter condition means constant expense and trouble to keep the pavement surface in satisfactory shape. A uniform wear, however, requires little if any expense for keeping the surface in satisfactory condition, and if not too rapid, will result in as much expense in the long run.

Most natural materials can be made into sufficient foundations for pavements if they are of the so-called "mineral kingdom." Vegetable matter ordinarily cannot be, and must be excluded from the foundation because of its tendency to instability. The question, however, as to whether to use the natural mineral material in place, or whether to substitute something else for it, is often mainly an economic one, and comprises, as will be seen, the question of whether or not the material is, and will be sufficient for the purpose in its natural state and the question of what it will cost to preserve it indefinitely in a satisfactory condition, or what it will cost to remove the material and substitute therefor something else more satisfactory. The decision should be on the safe side, if for no other reason, because of the probabilities of unexpectedly severe strains eventually coming on the foundation. The modern tendencies are toward the more severe use of roads and streets with greater demands on their foundations than heretofore, and these tendencies should be recognized. On the other hand, the need for economy is equally rapidly growing greater, and if, as the old definition has it, "the engineer is a man who can do with one dollar what any fool can do with two," the demands of economy—i. e., true economy in the long run, must be recognized and sought by him.

---

*Extract from a paper read at the Canadian and International Road Congress.

The decision in this matter at present must be made largely on the basis of judgment founded on general knowledge and experience. There are few scientific data recorded to guide one in the matter though there are some. It is admitted that the stresses from the load on the surface of the pavement passing down through the body of the pavement itself are distributed over a larger area of the foundation. The supporting powers of various kinds of earth have been approximately determined. If now, some conclusions can be reached as to the distributing effect of the stresses through the surface of the pavement, a fairly accurate determination of the questions concerning the use of the natural material or the substitution of other material for the foundation of the pavement surfacing may often be had.

HANDLING OF WATER MAIN EXTENSION PROJECTS AT WASHINGTON, D. C.

The following set of instructions was formulated to govern the making up of a water main extension project in the water department of the District of Columbia. Such instructions make for smooth handling and efficiency in water department work:

1. Take time card from future-work hook, enter time opposite name and place card on work-in-hand book.

2. Get file and memoranda bearing number from Mr. Heins' "In Box." The memoranda made by Mr. Albert gives the proposed location and size of the new main, together with the existing mains with which the proposed main is to connect. If the project originates in the Water Department there will be no file.

3. Go to Mr. Robertson's room, No. 402, and see if the street is improved or unimproved, and if an approved grade is established. If the street is unimproved, but with an approved grade, make up the project on paper and linen (as hereinafter described), show the approved grade, but do not show the profile. The paper tracing is sent to Division D for levels, and Grant makes one blueprint of linen tracing, and sends it to the assessor. The linen tracing is completed upon the return of the levels by platting on the profile. Should there be no approved grade the linen and paper tracings are made as before described, but the file is sent to the Surface Department with request that an approved grade be established, while the paper tracing is sent to Division D for levels; upon the return of the levels and the file with approved grade the linen project is completed. When a street is paved or improved it is considered to be to the approved grade, and no paper tracing is required, excepting where a very old road is gravel or macadam, in which case a paper tracing is required.

The best method to look for grades is to go to the grade sheets first. These are arranged alphabetically, numerically, and by square (block) numbers, and the latest approved sheet in point of time should be taken. If there is no grade sheet, go to the map index, where the number for the desired map, if any, may be obtained. The map should only be taken as good when approved. The character of the streets within the city limits may be obtained in Mr. Hunt's room, adjoining Mr. Robertson's room, and, when outside of the city limits, they may be obtained from the wall map in the County Roads Division, room 412.

4. Having ascertained the character and grade of the street, the paper tracing sketch or tracing on linen should be made as follows: Both the tracing paper and tracing cloth should be 8x10 in. or of a size obtained from any multiple of either or both of these two dimensions.

5. When making up a paper tracing the sketch is to be made in pencil, showing:

A. The streets in which the proposed main is to be laid, with their widths, the lots which are abutting on the proposed main (Mr. Clarke's room, No. 107, assessor's office). The lots are to be designated by number or letter, and their frontage is to be given, and depth when on corners.

B. Any grades and profiles which are approved on the street where the proposed main is to be laid (Mr. Robertson's room, No. 402, Surface Division).

C. All water mains, fire hydrants, valves, etc., on the street where the main is to be laid, or on intersecting streets (Water Department, room 310).

After the above information has been traced on the paper and an arrow point denoting the north is placed on the tracing, the name of the draftsman and date compiled should be added to tracing. Enter time on card and forward card, memoranda, tracing, and file, if any, to Mr. Heins.

6. A project is to be made up, complete, on linen, either when there are approved grades or when the street is practically to grade. After a paper tracing has been sent to Mr. Heins it is returned with grades noted on by the engineers. When a linen tracing is to be made it is the easiest to first get all the data in pencil and then ink in. The following data are necessary:

A. The streets upon which the proposed main is to be laid and lots which face on any part of the street in which the proposed main is to be laid. The width of these streets and all intersecting streets must be given with the frontage of the lots. When the lot is on the corner or exceeds 100 ft. in depth, or where the lots run back to some other street or road, the depth of such lots must be given. This information is to be obtained from Mr. Clarke's office, room 107, assessor's office.

B. Where there is a roadway and curbs the width of same should be given. Sidewalks, where there are any, should be given, with their location and character, when the proposed main is to be laid outside of the roadway. When the main is to be laid in the roadway, only the curb line need be shown. The character of the street in all cases must be given, together with the latest approved grades. This information is to be obtained from Mr. Robertson's room, No. 402, and County Road Division, room 412; this latter room only for the character of county roads and streets.

C. All sewers must be shown which are in the street in which the proposed main is to be laid, and also the sewers in any intersecting streets shown on project. The sewer traps, manholes, and sizes of sewers must be shown. This information is to be obtained from Mr. Donovan, Sewer Department, room 300.

D. All underground construction which comprises electric, telephone, and telegraph conduits and gas mains should be shown on project where such construction would cross or is on the same side of the street as the proposed main. This information is obtainable from Division of Underground Construction, room 411.

E. All water mains which are in the street in which the proposed water main is to be laid are to be shown with the valves and fire hydrants *connected thereto; also the size of the mains and the kind of valve. This also applies to mains in any intersecting streets to the one where the main is to be laid. This information may be obtained from room 310, Water Department.

Having the necessary data in pencil on the tracing linen, it should be inked in as follows: All lines are to be of black ink. Building lines should be shown in a heavy line, the curbs and sidewalks in a fine line. Water mains are to be shown in a very heavy line, solid where old and dashed where proposed. Sewers are to be shown in moderately heavy dot and dash lines, conduits in three dots and a dash line, and gas mains in two dots and a dash line. After inking in project and putting on a north point, get project stamp from Mr. Grant's table and stamp tracing, fill in blanks of stamp, and the draughtsman should in addition add his own initials and the map number from which he got the streets (Clarke's office) and also the number of the grade sheet or grade map (Mr. Robertson's office).

7. After tracing has been completed the time should be entered upon time card. This card should then be placed on the work-in-hand hook of the draughtsman who is to check the project, and the memoranda file (if any) and project are forwarded to the checker.

8. The draughtsman who is to check the project takes the card from his work-in-hand hook, and notes time on the card and proceeds to check the project by going to the various rooms and through various steps described above in making the project, noting any errors on the project in pencil. After completing checking the tracing, he enters time completed on the time card and returns the project, memoranda, file and card to draughtsman who made project.

9. This draughtsman makes any necessary corrections on the project, and then returns same to the checker, who, upon noting the corrections have been made, initials the project. The draughtsman enters on the time card the time necessary to correct and clean the project.

10. The card, file, memoranda and tracing are forwarded to Mr. Heins' "In Box."

Procedure Required in Handling Projects in Unimproved Streets.—Projects for unimproved streets require that a paper tracing be made and levels requested. The paper tracing is made first and sent forward immediately through Mr. Proctor for levels.

The cloth tracing is then made up, without profile of street, and is checked only for correct names of streets, square numbers, lot frontages, and length of proposed main, and one print is made.

The endorsement is written transmitting file to the assessor, and the file, blueprint, and tracing are given to Mr. Proctor, who forwards the file and blueprint and retains the tracing until the level sheet is received.

---

*All fire hydrants within a reasonable distance of the proposed main must be shown.

He then gives the level sheet and tracing to the draftsman that made it. The profile is then added, and the project receives a complete checking and is signed by the checker and turned over to Mr. Heins.

Mr. Heins initials it and Mr. Albert and Mr. Garland stamp it, and it then comes to Mr. Grant's "In Box."

Mr. Grant has a blueprint made which becomes part of the file and replaces the first one sent to the assessor.

The project is then sent to the pumping station for 10 prints.

Before sending the project to pumping station be sure that it contains the initials of Mr. Heins and the stamps of Mr. Albert and Mr. Garland.

When the blueprints are received file them with project under "Current Projects."

These instructions are signed by C. P. Heins, Chief Draftsman. Mr. J. S. Garland is Superintendent of Water.

CHOOSING THE NEUTRAL AXIS CURVE FOR REINFORCED CONCRETE ARCHES.

Various methods are in use for determining the proper curve for reinforced concrete arches, and in many cases of design there appears to have been no attempt made to determine the best curve for the conditions existing. The following data on choosing the neutral axis curve for reinforced concrete arches were abstracted from a paper by B. J. Lambert, presented before the Iowa Engineering Society.

There are plans on file at the University of Iowa in which the engineer has used a parabolic curve for the neutral axis in a spandrel filled arch; others in which a circular curve is used under similar conditions; and still others in which compound curves of various kinds are employed. It is difficult to explain why one man chose the parabola (which is flat at the haunches and sharp at the crown), while another used an approximate ellipse (which is flat at the crown and sharp at the haunches), each working with practically identical spans, rises and loadings, unless one of the men at least was unfamiliar with a good method of choosing a satisfactory curve.

Among the various published methods of choosing the arch curvature may be mentioned those of Luten, Reuterdahl and Greene. Mr. Luten chooses for the intrados a curve half way between an ellipse and a circular arc through the assumed crown and springing points, and as an extrados curve the arc of a circle. Concerning this method Mr. Reuterdahl says: "While it is satisfactory in many cases it has the disadvantage that if the neutral axis is to be an arc of a circle, which is very desirable, it may often happen that the distance from a point on the neutral axis to the extrados may not equal the distance from the same point on the neutral axis to the intrados, the distance being measured radially." Mr. Reuterdahl in his book on arches advises the use of a circular arc for the neutral axis, irrespective of span, rise and loading. He is nearer correct than the man who uses a parabola, and his scheme is simple and expeditious, but it sometimes lacks that very desirable feature, namely, as close an approximation to accuracy as can reasonably be expected from the use of certain rational formulas and processes.

In Greene's book on arches there is described a method of drawing a transformed catenary—a curve which is satisfactory for certain types of arches and conditions of loading.

The most satisfactory process is based on the fact that no matter what the static loading and assumed arch dimensions, it is possible to find a neutral axis that will be coincident with the equilibrium polygon of the assumed loads.

The greater part of the loads on a spandrel-filled arch is that due to the weight of the pavement, fill and arch ring. The live load usually forms a comparatively small part of the total load. Naturally, then, in choosing a neutral curve the greater emphasis should be placed on the effect of dead loads. If to the dead load a certain part of the assumed uniform live load be added, and an arch drawn whose neutral axis coincides with the pressure line of this loading, the results will be quite satisfactory. The writer is accustomed to using 50 per cent of the uniform live load over the whole bridge.

To show the effect of the live load on the equilibrium polygon the curvature for a reinforced concrete arch bridge was computed and drawn for three conditions of loading. The equilibrium polygon was constructed: first, for dead load alone; second, for dead load and a live load of 100 lb. per square foot over the entire bridge; and third, for dead load and a live load of 200 lb. per square foot over the entire bridge. The arch span of the bridge considered is 104 ft., the rise of the neutral axis 10 ft., the assumed weight of reinforced concrete 150 lb. per cubic foot, the assumed weight of fill 120 lb. per cubic foot, and the weight of the pavement 80 lb. per square foot.

It is of interest to note that, at about 20 ft. from the springing where the variation seemed to be a maximum, the equilibrium polygon for the three assumed loadings had a vertical variation of less than 2 in., i. e., the equilibrium polygon for dead load and a 100-lb. live load was about 1 in. below that for dead load alone, while the equilibrium polygon for dead load and a 200-lb. live load was about 1 in. below that for dead load and a 100-lb. live load. But it was also observed that the compound curve used as a neutral axis and drawn approximately to coincide with the equilibrium polygon for dead load and a 100-lb. live load was, at this same 20-ft. point, about 7 in. above the arc of a circle drawn through the crown and springing line. This shows clearly that the arc of a circle would be entirely satisfactory for this arch. It also shows the small effect a symmetrical live load has on the dead load curve.

It is the writer's custom to use about 1¼ times the crown depth for the vertical depth of the arch at the point of compound curvature, which is taken at about 1/5 of the span from the end; and 2½ times the crown depth for the vertical depth of the arch rib at the springing.

Due to gravity loads only the radial depth of the arch rib at any point equals the crown depth multiplied by the secant of the angle of inclination of the neutral axis tangent at the point with the horizontal, but temperature effects modify this considerably and no general rule for computing arch depths is applicable.

If an open-spandrel arch is planned it is customary first to design the floor slabs, beams, girders and columns, and with these loads definitely determined to proceed as before in getting the desired arch curvature.

It is quite generally agreed that the intrados curve presents a better appearance if it is compounded into the pier line. If possible, the radius of this curve should be so chosen that the so-called springing line is above the ordinary water level in order that the contractor will not have "water troubles" in joining the arch proper with the pier. This intrados fillet is not considered in computing the stresses.

Experimental Iron Removal and Softening Plant at Springfield, Ill.—An experimental iron removal and water softening plant has just been completed at the Springfield pumping station. It was installed by George C. Habermeyer, civil engineer, Aurora, Ill., under the direction of W. J. Spaulding, Springfield Commissioner of Public Property. It will be operated for at least three months. It is estimated that the cost of iron removal and softening will be about ½ ct. per 1,000 gal.

Winnetka is a suburb of Chicago. It has a population of about 3,500. Since Jan. 1, 1915, it has had a City Manager. This manager is a modest man. During the year he has reduced the salary roll of the water and light department $500 a month. Also, by efficiency studies he has reduced the cost bills of the plant $5,000. "Outside of these things," he says in a recent report, "there hasn't been a great deal accomplished." He hopes by next year to have something worth while to report.

THE DECREASING COST OF WATER SERVICE IN OMAHA, NEB.

Six times since July 1, 1912, when Omaha came into possession of its water works, have the water rates been reduced. The sixth reduction, 10 per cent in the maximum net water rate paid by consumers, became effective in connection with water used in April of this year and regularly billed on and after May 1. The effect of the preceding five water rate reductions, made since July 1, 1912, is rendered clear by an inspection of the accompanying diagram.

In 1900 the City of Omaha voted to acquire its water plant, then owned by a private corporation; however, as the result of a bitter contest, actual possession was not accomplished until July 1, 1912.

To finance the purchase and provide for necessary extensions and improvements, there were issued and sold $7,500,000 of "Omaha Water Bonds," from the proceeds of which $6,319,261.68 was paid for the plant.

During the 3½ years of public ownership, ending December 31, 1915, there has been expended in extending and improving the water plant $1,105,389.37, resulting in an adequate water supply of a purity and clearness never before enjoyed.

During the same period the percentage of services metered has been increased from 50 to 87 per cent, the maximum water rate charged under private ownership reduced 40 per cent, and another reduction of 10 per cent announced, and now effective, in connection with water used in April, 1916, and thereafter.

These changes, together with the reduced hydrant rental rates afforded, have resulted in a saving to small consumers and the city of more than $600,000 for the 3½-year period.

The water plant is conducted by the Metropolitan Water District of Omaha, under the managerial form of government, consisting of a bi-partisan board of six directors, two of whom are elected every two years for a term of six years, and a general manager appointed by the board.

The main pumping station is located six miles north of the business center of Omaha, where water is pumped from the Missouri River into a series of six sedimentation basins for treatment and purification. Thence it is pumped to the city against the head afforded by three reservoirs at an elevation of 307 ft. above the river, and subsequently 32 per cent is re-pumped at the Poppleton Avenue Re-pumping Station, located in the city, to the higher portions of Omaha.

The population of the Metropolitan Water District of the city of Omaha is 175,000.

For the year 1915 the saving to the small consumers approximated $263,363 due to a change in the form of service and a 40 per cent reduction in the maximum water rate. For the same period the saving to the city was $12,762 due to the installation of a large number of hydrants without a corresponding increase in taxation. These two items, amounting to $276,125, form a saving in addition to the net profit from operation of $217,985, of which $130,034.49 was placed in the Bond Sinking Fund and $87,951.26 added to surplus. The approximate saving and net profit thus amounted to $494,110 from which should be deducted $129,703, the probable maximum amount of all taxes which would have been payable under private ownership. (For the year in which water bonds were first voted for the acquisition of the water plant the total taxes paid the city by the water company amounted to but $14,747.32.)

For this information we are indebted to Mr. R. B. Howell, secretary and general manager.

Use of Hypo at Waukegan, Ill.—During December, 1915, Lake Michigan water was dosed with hypo at the rate of 6.88 lb. per 1,000,000 gal. of water used. The strength was 0.334 p. p. m. average available chlorine. Water temperature averaged 38° F. In the raw water B. Coli present 7 days. There were no gas formers present during the month in the treated water.

RAILWAY ELECTRIFICATION AND CHEAP WATER POWER.*

Electrification of railroads, like the production of atmospheric nitrogen for fertilizers and explosives, is suspended in the United States pending the enactment by Congress of general laws which will make possible the development of cheap water power in large units. That is to say, these lines of development are dormant, save as to localities where electricity can be produced more cheaply by steam than by water power.

The high price of coal, the excessive cost of operation, and a general crusade against the smoke nuisance has created the demand for electrically operated railroads, but the substitution of electric for steam locomotives is being held back in many localities because existing laws are such that capital will not undertake water power development under their terms and restrictions.

Only recently the Chicago, Milwaukee & St. Paul Railway completed the electrification of 440 miles of its main line between Harlowton, Montana, and Avery, Idaho. This portion of the Milwaukee railroad crosses the main range of the Rocky Mountains and embraces the heaviest grades on the Milwaukee sytem. It is equipped with electric locomotives of 3,000 h.p., and is operated by power purchased from the Montana Power Co., a company which acquired title to its power sites before the Federal Government entered upon the policy of withdrawing power sites from entry.

The Norfolk and Western Railroad hauls heavy trains over its mountain grades with 6,000 h.p. locomotives, and finds that two electric locomotives are equivalent in efficiency to the three Mallet steam compound engines formerly used. As this road is now operated, the locomotives become dynamos on the downgrade, generating power from the motion of the descending train and returning to the overhead trolley a considerable portion of the current used in climbing the hill.

The most extensive main-line railway electrification in the United States, or in the world thus far, is that of the New York, New Haven and Hartford Railroad, which has electrified upwards of 500 miles of track leading into New York City, and is operating more than 100 electric locomotives and a slightly lesser number of multiple-unit cars. This road's electrification includes its Harlem division freight yards, which are among the largest in the world, and its motor equipment includes high-speed engines for passenger service, heavy engines for freight and express service, and slow engines for switching service. The power for this electrical service is generated from a steam plant at Stamford, Conn.

The operation of the West Jersey and Seashore Railway, between Philadelphia and Atlantic City, by electricity, is from current generated by steam, as is also the electrified division of the Pennsylvania Railroad from Newark, N. J., to New York, through the Hudson River tunnel. Power for the operation of the Grand Trunk trains through the tunnel under the river at Detroit, Mich., is sold to the railroad by the local power company.

The experience of the Milwaukee and of the Norfolk and Western railroads has demonstrated the superiority of electric motive power over steam, particularly on the mountain grades. It is in the mountainous country that water power is most abundant, and in that region between the Missouri River and the Pacific Ocean, where the heaviest grades are found; and where also may be developed the greatest quantity of cheap water power, coal is most expensive.

Statistics gathered by the Interstate Commerce Commission disclose that beyond the Missouri River the cost of fuel for locomotives amounts to from 12.7 to 12.8 per cent of the total operating expense; on the roads of the East the coal cost is much lower, 6.9 per cent on the Pennsylvania and 7.5 on the Illinois Central. The water powers of the West, where coal is scarce and expensive, consequently have a relatively higher potential value for this use than they otherwise would possess, and the demand for their development for transportation uses is the greater, but development does not progress, because of the lack of proper laws governing power development on the public domain.

---

*From the Water Power Development Association, Munsey Bldg., Washington, D. C.

Water power, to be utilized in transportation, must be developed in large quantities, and developed cheaply. The late E. H. Harriman, shortly before he died, thought he saw great possibilities in the substitution of electricity for steam on the Union Pacific system, and particularly on the Sierra grades. When he had made surveys and estimates he found that while, by electrifying the Union Pacific through the Sierras, he could save from $350,000 to $375,000 a year in fuel costs, this saving would be fully absorbed by the interest charges on the large investment of capital necessary to make the change from steam to electricity and to develop the water powers, which the railroad proposed to do itself. The Union Pacific has never been electrified. But the Milwaukee, crossing a country where water power is being cheaply developed and can be sold to the railroad at low rates by a power company, found it a good business venture to discard steam on its mountain divisions, and the success of the first experiment justified the adoption of electricity as motive power for the full length of the mountain run.

Cheap water power and plenty of it, and opportunity to develop this power under favorable circumstances, are absolutely essential in order that electricity may be substituted for steam as motive power on the railroads, east or west. This is essentially true because of the steadily diminishing cost of generating electricity by steam turbines. The turbine of today uses 20 per cent less coal than did the steam engine of 15 years ago, and the cost of installing steam plants has undergone an even greater reduction. A 5,000 kilowatt turbine-driven unit today costs, to install, about $12 per kilowatt, while the cost of the engine-driven units of 15 years ago was $36.60.

Because of the heavy costs of installation, and because of the ever diminishing cost of steam plants, water power development, to successfully compete with steam, must be cheap and must be in large units.

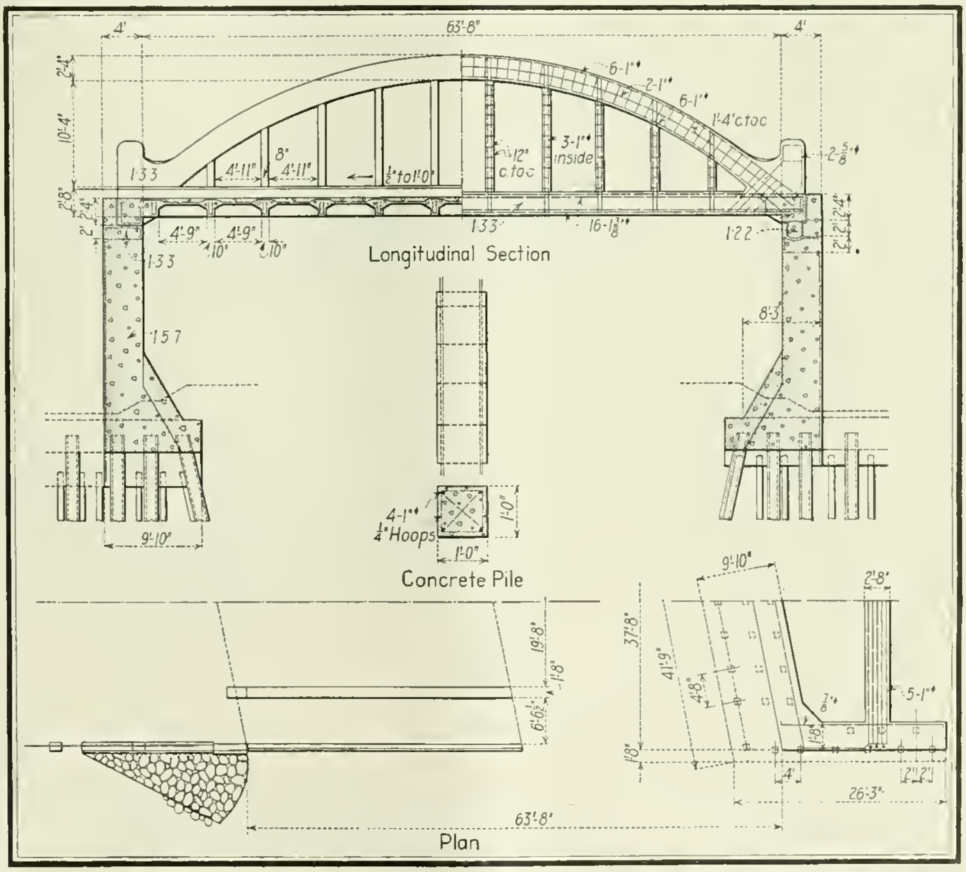


Fig. 1—Sectional Elevation and Plans of Reinforced Concrete Through-Arch Bridge at Kristianstad, Sweden.

DESIGN AND CONSTRUCTION OF A THROUGH-ARCH REINFORCED CONCRETE BRIDGE AT KRISTIANSTAD, SWEDEN, WITH COMPARATIVE DATA ON THE DESIGN OF THE LYONS FALLS BRIDGE IN NEW YORK.*

Contributed by Albert M. Wolf, C. E., Chicago, Ill.

As the means of comparing American and European practice in the design and construction of through-arch bridges of reinforced concrete the following description of the arch bridge built in 1914 at Kristianstad, Sweden, and that of the bridge at Lyons Falls, N. Y., built about the same time and described in the Feb. 16, 1916, issue of Engineering and Contracting, are excellent. The first-mentioned structure, with a clear span of 63 ft. 8 in. and a clear roadway of 19 ft. 8 in., is built entirely of reinforced concrete, while the Lyons Falls bridge, with a clear span of 56 ft. 8 in., is built almost entirely of structural steel members encased in concrete. Herein lies the great difference in American and European bridges of this type; practically all the European structures have all members reinforced with ordinary reinforcing bars, while the American engineer seems to be adverse to trusting to bars for the main members (ribs, ties, and hangers), evidently on account of the necessity and difficulty of obtaining an absolute connection between the reinforcing members. If the structural steel frame to be encased is so made as to allow the supporting of forms therefrom during concreting some advantage will be gained under conditions which make the use of falsework undesirable; as a general rule, however, the bridge with the rod reinforcing will be the cheaper, due to the fact that the steel is placed as to act more efficiently. In Table I the main dimensions and details of the structures mentioned are listed, which offers an interesting comparison of the two bridges.

The Kristianstad Bridge.

Design.—In the summer of 1914 the board of direction of the Kristianstad Hessleholm Ry. asked three firms for

---

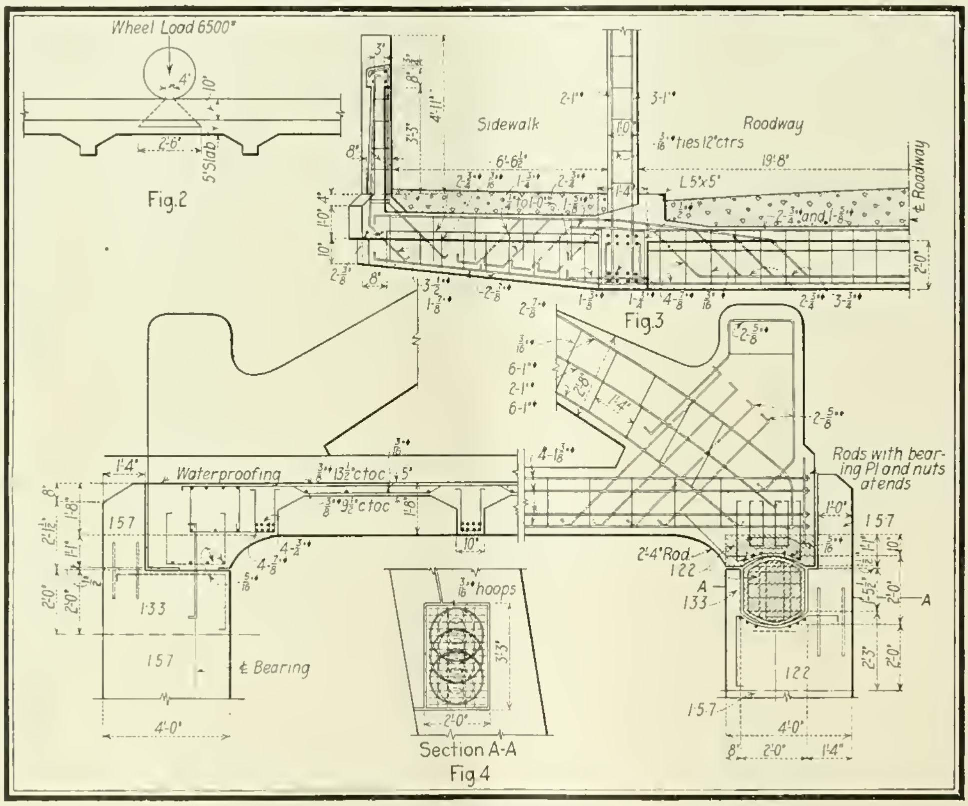
*Based on translation of article by David Andersson, of Malmoe, in Beton u. Eisen of Jan. 4, 1916.

TABLE I.—COMPARATIVE DATA ON DIMENSIONS AND REINFORCEMENT OF LYONS FALLS AND KRISTIANSTAD BRIDGES.

Bridge.	Clear span.		Rise of arch.		Overall width.		Clear width between ribs.		Floor thickness, excl've of paving.		Design load.	Arch ribs		Horizontl ties		Hangers			
	Ft.	In.	Ft.	In.	Ft.	In.	Ft.	In.	Ft.	In.		Dimensions at crown.	Reinforcement.	Dimensions.	Reinforcement.	Spacing. Ft.	In.	Size.	Reinforcement.
Lyons Falls, New York	56	8	10	0	25	9	18	3	2	0	15-ton truck.	1 ft. 8 in. deep x 3 ft. 6 in. wide.	4 Ls. 3x3x 5/16 in. 7.12 sq. in.	1 ft. 3 in. deep x 4 ft. 4½ in. wide.	4 Ls. 3½x3 x7/16 in. 2 Pls. 7½x ⅜ in. 16.2 sq. in.	7	1	10 in. x 2 ft. 10 in.	4 Ls. 3x3x ⅜ in. 8.44 sq. in.
Kristianstad, Sweden ..	63	8	10	8	38	0	19	8	1	8	100 lb. per sq. ft.; also 13-ton truck, axle spacing 11 ft.	2 ft. 4 in. deep x 1 ft. 8 in. wide.	14 bars 0.98 in. round. 10.5 sq. in.	2 ft. deep x 1 ft. 4 in. wide.	16 bars 1⅜ in. round. 24 sq. in.	5	7	8 in. x 12 in.	5 bars 0 98 in. round. 3.75 sq. in.

Note: Lacing for structural members of Lyons Falls Bridge and ties for reinforcement of Kristianstad Bridge not included in reinforcement as listed.

proposals and estimates of cost for a highway bridge over the tracks of the north section of the Kristianstad terminal.



SOME DETAILS OF REINFORCED CONCRETE THROUGH-ARCH BRIDGE AT KRISTIANSTAD, SWEDEN.

Fig. 2—Sketch Showing Assumed Distribution of Wheel Load. Fig. 3—Half Cross-Section of Bridge Showing Reinforcement of Roadway and Cantilever Sidewalk Beams. Fig. 4.—Details of Fixed and Movable Bearings of Bridge.

Some of the conditions imposed were: That the construction falsework should not interfere with the track clearance lines below; the depth of floor should be as small as possible; and the roadway have a width of 19 ft. 8 in., with walks 6 ft. 7 in. wide. at each side. It was also specified that the statical analysis should be made on the basis of a uniform live load of 100 lb. per sq. ft. (500 kg. per square meter), and that the influence of a 13-ton truck, with axles 11 ft. apart, should be investigated.

The contract was let to the A. B. Skanska Co. of Malmoe, for an arch bridge with suspended roadway, since, on account of the very limited depth of construction allowable, practically no other scheme could be considered.

Since a firm soil was found only at a considerable distance below the ground line, and since the ground water level was low, concrete piles 12 in. square in section were driven for the abutment foundations. These piles, which were designed to support loads of 44,000 lb. each, were made of a 1:2:3 concrete, and were reinforced with four round bars, each having a cross sectional area of 0.75 sq. in., tied together with ¼-in. diameter hoops spaced about 1 ft. on centers. The abutments, which are reinforced along the back face, were built of a 1:5:7 concrete, with a 1:3 mortar around the reinforcement. The arrangement of the concrete piles in the abutment footings and wings, together with the reinforcement in the abutments, are shown in Fig. 1.

The main members of the superstructure consist of two reinforced concrete arch ribs, 1 ft. 8 in. wide, with a crown depth of 2 ft. 4 in. and a depth at the haunches of 2 ft. 8 in. From these ribs are suspended the hangers which carry the roadway. The horizontal thrust of the arch ribs is taken up by sixteen 1⅜-in. round bars embedded in longitudinal beams and anchored to plates at the ends. Between the two arch ribs, which are spaced 19 ft. 8 in. apart, lies the roadway, while the walks are carried on cantilever beams, which extend 6 ft. 7 in. beyond each arch rib. The roadway slab, which is 5 in. thick, is carried on cross beams spaced 5 ft. 7 in. on centers, at the hanger panel points. These beams cantilever out on each side to support the sidewalk slabs.

To allow plenty of movement, due to expansion and to the loading, the superstructure is anchored to only one of the abutments, and rocker hinges of reinforced concrete are provided at the other end of structure, under each rib.

The slabs are designed as continuous over the beams for the wheel loading, which is distributed as shown in Fig. 2. Clapeyron's formula for beams continuous over five supports gives as the maximum moment 4,600 ft. lb., which, for a 5-in. slab reinforced with 0.39-in. diameter spaced 4⅜ in. on centers, gives a compressive stress in the concrete of 525 lb. per square inch, and a tensile stress in the steel of 14,215 lb. per square inch.

The cross beams were designed as freely supported beams with cantilever ends. After considering the different conditions of loading the beams between the suspenders were proportioned for a moment of 77,360 ft. lb., and the cantilevers for a negative moment of 52,050 ft. lb. Special provision was made to care for the shearing stresses, by means of the hanger connections and stirrups. The shearing stress, after making due allowance for bent-up rods, is 64 lb. per square inch, and the bending stresses do not exceed 568 lb. per square inch compression and 14,200 lb. per square inch tension.

The hangers each carry a load of 36,685 lb. and they are so designed as to resist side wind pressure in addition to direct load; they are reinforced with five 0.98-in. diameter bars, three of which are on the roadway side of the hanger. Details of construction of these hangers are given in Figs. 1 and 3.

The form of the arch curve and the proportions of the ribs were next ascertained graphically by the use of pressure lines, and the exact computations were then made with the aid of the elastic equations for a two-hinged arch with a horizontal tension tie.

The arch is symmetrical with an axis having the curve of a flat parabola with a rise of 13 ft. 1½ in. and a span of 65 ft. 7½ in. The moments and normal thrusts for the various sections were found by means of influence lines. The division lines for arch sections were taken so as to correspond with the intersection of the lines of hangers with the arch rib. The stresses, in general, were computed on the basis of allowing tensile stresses in the concrete. The largest tensile stresses occurred at the point over the second hanger from the crown. This point was therefore also investigated for the assumption of no tensile stress being allowed in the concrete. The moment at this point is 198,400 ft. lb.; the normal thrust is 237,810 lb.; the eccentricity is 10 in.; and the unit stresses are 702 lb. compression in concrete, 1,803 lb. tension in steel, and 9,940 lb. compression in steel.

As already mentioned, rocker hinges were used on one abutment. The design of these hinges was made in accordance with the theory of Hertz, using the formula—

$$b=4\sqrt{\frac{2p}{\pi E}\cdot\frac{1-\frac{1}{m^2}}{\frac{1}{r_1}+\frac{1}{r_2}}},$$

in which $E=2{,}030{,}600$, $r_1=1$ ft. 10 in., $r_2=2$ ft. and $m=3$. The value of b is found to be 3 in. The bearing stress on the concrete for this condition is 2,627 lb. per square inch.

Construction.—To make the hinges as accurate as possible they were constructed in an artificial stone factory in Malmoe, under the direction of the technical bureau, rather than on the site. The details of the hinges and of the connections of arch ribs and abutments are shown in Fig. 4. The concrete for the hinges is a 1:1:1½ mixture.

The abutment seat for the hinge was very carefully built to the given radius, and the hinge set thereon at a later time. A concrete slab cast at the same time as the hinge was then placed upon the latter and rigidly connected to the superstructure by projecting the tie bars into the arch rib concrete.

Since traffic on the railroad tracks could not be interfered with during construction it was necessary to design special falsework, which would leave an open space for two tracks at one end of the bridge.

A special facing concrete, which later was bush-hammered, was used on the abutments; otherwise the entire bridge is treated simply with a cement wash.

The excavation and placing of concrete piles was started in the early part of October, 1914. By the end of November the abutments had been placed and the falsework and forms for the superstructure completed, so that the concreting of the roadway slab could be started. The hangers were not encased in concrete until after the falsework had been removed, to prevent cracks forming in the concrete due to their deformation under dead load.

Shortly after the completion of the concrete work a long and severe cold spell set in, so that the falsework could not be safely removed until the beginning of April, 1915. On striking the centers the entire structure settled about ⅛ in. Under the test load, later applied, scarcely noticeable deflections were observed.

Advantages of Through-Arch Construction.

When one considers the several advantages of through-arch bridges over the usual deck arch design it is rather surprising that more of them are not used, especially for highway bridges. The through arch is especially adapted to low crossings of over 50-ft. span, where a deck arch with the same roadway load would cut down the river prism or underclearance too much. This type combines the advantage of long-span concrete construction, made possible only by the use of arched members, and the comparatively thin floor system available in short-span slab or beam-and-girder bridges. The use of horizontal ties to take the arch rib thrust decreases the size of abutments necessary, since only vertical load has to be carried, in so far as the arch itself is concerned. The effects of temperature on the arch ribs are rendered practically negligible by placing the arch ribs (with horizontal ties on rocker or sliding bearings. The features just cited permit a much lighter structure than with other types of reinforced concrete construction. A through concrete arch for highway traffic can be built at less cost than a steel bridge with concrete floor fulfilling the same local conditions. As regards appearance, a carefully proportioned through arch with parabolic curve (the theoretically correct curve for this type of loading) will be found a much more attractive and pleasing structure than a concrete girder bridge or any form of steel structure.

In Europe, through arches of 197-ft. span have been built for both highway and railroad traffic, while a great number of shorter span structures of this type have been used to bridge canals, roadways and railroads. A review of American practice reveals the fact that only one really long-span through arch bridge has been built, namely, the Fifth St. Viaduct at Fitchburg, Mass., the main arch span of which is 193 ft. 7 in. between abutments; all other bridges of this type have spans of from 50 ft. to 100 ft. This would seem to indicate that there is still considerable room for advancement in the design and use of this class of structure in America, and that much of material advantage can be gleaned from European practice.

SYSTEM OF ROAD WORKING IN WARREN COUNTY, KENTUCKY.

Contributed by M. H. Crump, County Road Engineer, Bowling Green, Ky.

This county has 563 square miles, with 1,000 miles of road, of which 400 are water bound macadam and gravel and 600 are earth. About 75 per cent of the area carries excellent limestone of the Mississippian formation, with rarely ever more than one-half mile haul to the road that is being improved. The main roads leading from the county seat, Bowling Green, are 16 and 18 ft. wide to the county line; the secondary roads are usually 9 and 14 ft., containing from 900 to 1,400 cu. yd. of metal per mile, respectively.

The average cost of the stone on the roads including grading and drainage, is $1.50 per cubic yard. For the 9-ft. country roads leading to the market places and the main roads, the cost to the tax-payers is reduced to $500 per mile by reason of the fact that on such roads the land owners along the roads and occasionally the quarry, do all the hauling gratuitously. This reduces the cost per mile to $350. The gravel roads 9 ft. wide with 1,200 cu. yd. of unscreened gravel cost the taxpayers $300 per mile.

The rule has prevailed here for more than 25 years never to improve a road unless the property owners along the road contribute at least $500 to $1,000 per mile. When grading is to be done the county furnishes the grader and operator and the farmers furnish the mules, usually three pairs, as long as is necessary to grade the particular mile in question. The county owns four complete crushing outfits including rollers. For taking care of the 600 miles of earth roads, a foreman is selected from the very best farmers in the magisterial district, who furnishes a first class pair of mules, not less than 1,200 lb. each, with wagon and driver; he is paid during the working season, some six or eight months, 20 ct. per hour for himself and 30 ct. per hour for his team. He is supplied with a complete outfit for a crew of 12 hands, including a grader. The hands composing the crew are paid 12½ ct. per hour; when the crew falls to 7 men, the foreman gets 15 ct. per hour, when it reaches five he becomes a laborer at 12½ ct. per hour. This is done automatically. It rarely happens that a foreman has less than a full crew. These crews are composed of laborers from the district, which usually has 100 miles of road, and if possible at least two men of the crew must live on the road that is being worked for the reason that they are familiar with the weak spots in the road, which we all know presents a very different appearance in July and in January or March. The laborers are responsible for their tools and the condition of same.

There are eight magisterial districts (townships) and with the four crushing outfits there are 12 foremen. The County Engineer deals with these 12 men only and handles them very much as he has controlled a regiment. Each foreman is responsible for his tools, the condition of his crushing outfit, etc. He reports to the County Engineer on each Saturday during the working season at noon with his pay roll made out. He is placed at a table where the warrants are all filled out by him for each laborer, frequently amounting to 150. For 12 crews the warrants are all signed by the County Engineer and countersigned by the County Judge. Next they go to the Sheriff who takes out any taxes due the State or County and pays the remainder in cash, or if nothing is due simply endorses the voucher which becomes a check and may be cashed at any bank or store. All this work is done in less than three hours, and the hands usually spend their money by Monday morning when it is necessary for them to begin work again. When work is being done some miles from town, the foreman attends to the warrants and pays them over on Monday. A voucher is thus kept for everything that is done and every cent that has passed through this office since March 4, 1912, is accounted for.

The road fund consists of 25 ct. on the $100 property tax and a poll tax of 25 ct., which produces a fund of about $40,000 per year. With this sum and the gratuitous work from the energetic and patriotic citizens who are striving to get out of the mud $80,000 to $100,000 worth of work is done annually. For the first time the State came to the aid of the county last year, 1915, with $15,000 which was used in building a steel bridge with reinforced concrete floor surface with Kentucky Rock Asphalt. In addition 12 miles of the Dixie Highway, between Louisville and Nashville were resurfaced with macadam at a cost of $2,000 per mile. In addition to the above 8.92 miles of waterbound macadam were constructed; also 4.5 miles of gravel road; 253.3 miles earth road were graded, drained and the surface put in such shape that a horse and buggy could easily trot over it. The latter is the specification for earth roads. The road engineer drove 3,699 miles, 75 per cent of which was with a horse and buggy.

COST OF GRAVEL ROADS IN CLAY COUNTY, IOWA.

Gravel roads, Class B of the Iowa Highway Commission, are constructed as follows: Gravel is placed on the road crown and disked and harrowed to secure even distribution; traffic is depended upon to do the compacting. In Clay County, Iowa, one coating of gravel cost as follows:

Location.	Yards.	Av. haul.	Cost	Yard-miles.	Cost per yard-mile.
Sec. J	632	1.2	$ 411.10	756	$0.542
Sec. K	717	1.85	548.00	1,276	.429
Sec. L	717	1.25	452.25	896	.505
Sec. M	540	0.40	178.75	216	.827
Sec. P	811	2.75	807.62	2,230	.361
Sec. Q	801	3.75	1,136.88	3,004	.378
Sec. R	762	4.75	1,282.25	3,619	.355
Sec. A	661	5.00	1,214.00	3,305	.367

It will be noted that the cost per yard mile increases as the average haul decreases due to the fact that the cost of loading is an increasing factor as the haul becomes shorter. County Engineer Walter Barbour of Clay County, Iowa, reports these costs to the Iowa Highway Commission.

Missouri University Extension Aid to Good Roads.—The Extension Division will write to every road commissioner, supervisor and overseer in Missouri and send material on good roads without charge. Dean E. J. McCaustland was asked to prepare the material, and one bulletin already has been printed. Others will follow at intervals of about one month. Questions are encouraged and will be answered by the men of the School of Engineering who are experts on the subject of good roads.

The first bulletin was sent to more than 2,000 road commissioners, supervisors and overseers. It is estimated that there are 3,700 in the state, and this material will be sent to all as soon as their names and addresses are obtained.

The first bulletin is on "Country Roads" and takes up the drainage problems met in building ordinary dirt roads. It was written by F. P. Spalding, professor of civil engineering, and edited by Mr. Williams, secretary of the Extension Division. Another bulletin will be devoted to other phases of road construction and maintenance. Each bulletin is prepared, printed and mailed at the expense of the Extension Division. The object of it all is to make this department a center for the spread of information on good roads and to build up a stronger sentiment for good roads throughout Missouri.

Wisconsin Good Roads Men Organize.—The Good Roads Association of Wisconsin has been formed. The purpose of the state organization is "to organize in one body all those who believe in good roads; to spread knowledge of the business necessity and wisdom of good roads; to show taxpayers that the form of road which is cheapest in the beginning is often the most expensive in the end; to see, as far as possible, that the financing of highways is based on sound principles; to work for the building and maintaining of state trunk lines running north and south and east and west; to aid the work of the highway department of the state in obtaining appropriations and to bring the pressure of sound public opinion to bear when highway appropriations and measures are before legislators for decisive action." Mr. C. C. Jacobus of Wauwatosa is president. It is planned to name 72 vice presidents; one for every county in the state.

Oppose Lower Water Rates at Lafayette, Ind.—Lafayette business men are opposing the proposal to reduce water rates, saying it is wrong to cut the revenue of the municipal plant, which is carrying a debt of almost $250,000. The Retail Merchants' Association, at a meeting held recently, adopted a resolution protesting against the proposed cutting of rates until the indebtedness has been paid off.

Engineering and Contracting

H. P. Gillette, *President and Editor*

Volume XLV. CHICAGO, ILL., May 24, 1916. Number 21.

Twenty-Five Dollars Monthly in Bonuses

First $12 Second $8 Third $5

¶ Short stories containing usable suggestions are wanted for our department entitled *Current Engineering Practice Briefly Recorded.* (See issue of May 3, 1916.)

¶ The character of article wanted is a plain, practical description of some simple and efficient structural detail or construction method, device or tool. Give costs if possible; provide sketches*, prints or photographs if practicable.

¶ *For all articles* published payment will be made at space rates.

¶ In addition, for the three articles ranking, in the opinion of the judges, first, second and third in order of merit, there will be awarded the bonuses stated above.

Instructions

(1) Articles must not exceed 500 words.

(2) As many articles as desired may be submitted by the same person.

(3) Awards will be to articles, not to persons, so it may happen that one person will receive all three bonuses.

(4) Contributors need not be subscribers.

(5) Literary excellence will not determine merit.

(6) Name, position or rank will not influence awards.

(7) Contest for May closes May 31.

(8) Awards announced June 7.

* Rough free-hand sketches that convey the principle w suffice. They can be perfected by our drafting department.

Get Busy and Get a Bonus

"ADVANTAGES ENJOYED BY FOREIGN EXPORTERS."

"Foreign nations have built up their ocean shipping, have granted low export railway rates and have combined their land and ocean transportation facilities to give their shippers ready entrance into their overseas markets. The United States has neglected its merchant marine until it is dependent upon its commercial rivals to deliver its goods."

"Realizing the necessity of banking and credit facilities to finance their transactions foreign nations have not only established connections with banking houses in every land, but have dotted the map of the world with foreign trade banks of their own. The few foreign branches of American banks have but recently been established and in most markets our exporters must depend on alien banks."

"British, French, German and other foreign traders have billions of dollars invested in foreign lands frequently on express conditions that supplies and equipment should be purchased in the country furnishing the funds. American investments abroad are comparatively small and carry no trade obligations with them."

"Foreign industries have developed numerous comprehensive combinations, often aided by their governments, which effectually unite their activities in foreign trade. American industries must depend upon their individual activities."

These are quotations from the report to Congress of the Federal Trade Commission. They tell the reason for America's small development of foreign trade.

ROAD ENGINEERING SUPERVISION COSTS.

In our last issue were data compiled by the State Engineer of Arizona on cost of engineering supervision in road work. We recall having seen no similar summary. Perhaps other compilers have been discouraged from publication by the uncertain results obtained. Truly, the discrepancies exhibited by the figures published elsewhere are not encouraging to the searcher, and the compiler realizing this fact as he states in presenting his results, deserves praise for not throwing his records aside. They are unique and interesting. That engineering and administration costs of road construction exceed in some states 14 per cent of the total expenditure is a fact deserving of note and of being memorized. So is the apparent fact that this cost averages probably not far from 10 per cent of total road expenditures. The concluding thought suggested is that states having road commissioners directing construction need to segregate more accurately their costs of road engineering supervision and administration.

THE BLAME FOR FAILURE OF CONTRACTORS IN GOVERNMENT LOCK AND DAM CONSTRUCTION.

A well known U. S. Army engineer, writing recently, says: "There is little doubt that the best class of contractors are not eager to bid on lock and dam construction under the engineer department." This statement is not only fact but it understates fact. Contractors are not merely not eager to bid, they are afraid to bid. And their fear is logical. Contractors more often than not make no profit in Government construction of the character named. Many contractors lose money. Frequently contractors are absolutely bankrupted. These experiences are not confined to unqualified contractors; they have been the lot of contractors qualified by long training—men progressive and diligent in the business. Why is this so? The answer made is: Exaction of the army engineers. This answer is literally correct, but it locates the blame somewhat unjustly.

The rigidity of Government specifications is deplored by the army engineers in the field. Generally, they urge that more latitude in interpreting specifications be given the contracting officer. Also they urge that in specifications the risk due to uncontrollable conditions be placed on the United States rather than on the contractor. Once these things were done one of the causes of complaint which contractors have against Government work would be removed. Authority to do these things is, however, not in the hands of the contracting officer and until those above him who have the power do them, he has no recourse from precise and rigid interpretation of the specifications as they are. Take also the limitations of the eight-hour law, which are another just cause of complaint. None but Congress may alter the terms complained of as being too drastic. Army officers generally acknowledge the objections and would be glad to have them removed. One might exemplify more at length but the point sought to be made plain is already evident. Much of the exaction charged by contractors to the army engineer in direct control of construction work is forced upon him.

Take again the most prolific cause of failure of contractors in Government lock and dam construction, the risk due to uncertain river conditions, and consider the contracting engineer's responsibility. The rivers on which such construction is most common are of very irregular flow. It is uncertain in any year how long the low water period permitting construction will endure, and it is uncertain whether there will be in any year a low water season which will permit construction at all. These uncertainties are fully understood by Government engineers and it is common practice to recognize them in establishing the duration of the construction period. For work requiring two good seasons to complete, for example, a construction period of three or four seasons is allowed. The assumption in allowing the extra time is that the contractor shall take advantage to the utmost of good season opportunity. The fault in this plan is that the contracting engineer has no power to expedite the work if the contractor chooses not to push construction when he has the opportunity. As a consequence the contractor is caught often by high water with his work partly completed. His own procrastination is the cause of his downfall, and not the insistence of the army engineers that specifications shall be obeyed.

It is not the purpose to belittle the contractor's justification for complaint of Government working conditions. This justification is great enough to demand remedy. It is, however, the purpose to indicate that cause for complaint does not lie in the hands of the contracting army engineer and that he should not be condemned for faults beyond his control.

AN INNOVATION DESERVING IMITATION IN WATER WORKS REPORTS.

For several years experiments in water softening and water purification of exceptional interest have been conducted at the new water works of Columbus, Ohio. As they proceeded to final results these experiments have been described, analysed and summarized in papers and articles written by the experts of the department and published in various technical periodicals. In this respect of giving to the engineering public early and authoritative information of constructive work in purveying potable water supply the operators at Columbus deserve high praise. But they have done almost equally praiseworthy service in their annual report for 1915 by assembling all of their technical discussions in one place for convenient reference. We have been at pains many times to urge in these columns just this action. It raises the city water department report at once to a plane of general and permanent value as a professional document. Usually such reports are wanting in interest to anyone, even including the city officials themselves.

A RECORD OF SERVICE TO HIS PROFESSION.

News of the death on May 16 of Elmer L. Corthell will be received with a feeling of deep regret by all who at any time enjoyed the personal acquaintance of this engineer and true gentleman. One's first impulse is to voice surprise at the news. So virile and so alert both physically and mentally was Mr. Corthell that it was only on second thought that one realized that the man had reached the advanced age when the summons of death may come at almost any time. When taken with his last illness, Mr. Corthell was 76 years old and he had practiced engineering for nearly 50 years. On another page a list of his more important professional engagements during this half-century of labor is published. This list comprises many engineering works of many kinds and some of them works famous in the engineering world. No schedule of work done and periods served gives, however, the understanding, that should be possessed by engineers, of the characteristics of the man or of his service to American engineering.

Twenty-five years ago the writer, then just beginning his work among men, was commissioned to obtain by personal visit to E. L. Corthell material for an article describing one of that engineer's works. The man interviewed had a matured reputation for ability based on a record of notable accomplishments. His interviewer stood at the opposite extreme of his labors. That the older man understood this great difference in position is beyond doubt, but he suffered no indication of that knowledge to escape him. He, with pains, explained his work and produced the plans and reports relating to it and these he annotated and described. As "mere suggestions" he scheduled on paper the features that his interviewer might find it desirable to mention particularly. Finally it would interest him greatly to read in proof the proposed article and to suggest any little additional thing that might occur to him. Doubtless there was included in all this painstaking the natural desire of the engineer to prevent a hashed record of his work from being printed, but the writer believes that a stronger impulse was the wish to aid a young man in putting an efficient piece of work before his employer. This incident is of no importance except as it illustrates the kindly disposition and unfailing courtesy of the man of whom it is related. In this kindliness and courtesy rests the secret of Mr. Corthell's particular service to American engineering.

This particular service was the establishment abroad of closer acquaintance with and a high respect for American engineering. In Spanish America and in Europe, where accomplishment in social intercourse counts much in securing an audience and favor, Mr. Costhell's presence and address were of transcendent value. They, no less than his engineering talent, established him unimpeachably and as Mr. Corthell was never else than an American wherever he was American engineering gained consideration and reputation. Few American engineers had so wide an acquaintance with foreign engineers of prominence as did Elmer L. Corthell and few have done so much to transmute that acquaintance into respect for his profession in his own country.

AN INSTANCE WHERE CONSIDERATION OF ROAD DRAINAGE WAS WARRANTED.

To the Editors: In your issue for April 19, you publish an editorial on "The Three Characteristics of Good Technical Articles" with which we agree. We also agree with the criticism of road articles being thrust upon us, and yet we still get stuck in the mud here in Iowa.

The enclosed photo was taken this spring on a graded portion of the Lincoln Highway about 1,000 ft. up from the foot of a hill. The party in the car was not posing. His engine was in good working order. He is not the writer, for the writer came on the scene after this car was in, so after helping to extricate the car shown he turned around and went back as many other cars had done meanwhile.

This road is not tiled, though the engineer's plans call for a tile drain. No objection was raised to the tile being included in the plans and just as little action was taken by those in control to have them put in the ground. Perhaps tiling is poor political play. Their presence is not apparent even though their absence is often noticeable.

F. O. Nelson.

Toledo, Ia., May 13, 1916.

HANDLING THE POLITICIAN.

To the Editors: We are truly up against an everlasting problem when it comes to handling the politician. He is not as docile as our long-eared hybrids even though he makes one of himself sometimes, not being entirely different from other divisions of the human race. We would first call attention to the most obvious manner of getting on an even footing with him: to be one yourself. That, both the thought and the deed, seems to have occurred to many already, else we would hesitate to call attention to it.

Of course that is dodging the question of unavoidable conflicts, but so are the conflicts being dodged. We may as well admit at once that engineers are nearly as far from perfect morally as others, while politicians are not much more imperfect. Standing firmly for what is good engineering practice requires moral intelligence and courage. We have been trying for some time to call attention to the need of moral intelligence; a knowledge of what is right and wrong and why it is so, not as applied to engineers and politicians particularly, but for all people. Emotional preaching alone is ineffective.

Many of these unavoidable conflicts between engineers and politicians are largely questions of right and wrong, morally and economically. To win it is necessary to make plain what is right to those who are willing to know, and to stand for the right against those who are for their own way, right or wrong. Right here is an important point. The engineer who stands for what is right often gets replaced by one with less scruples. In one case we know of the succeeding engineer proposed to do whatever "they" wanted done, leaving the responsibility on "them," as though responsibilities were easily shifted. If we remember correctly, it was in the news columns of Engineering and Contracting some years ago that we read of an engineer who was let out of his job, "it being reported that he paid too much attention to the interests of the taxpayers." It is also reported that one locality "had an honest engineer once, but couldn't use him." Who won, the honest engineer or his successor?

While this question may be profitably discussed we do not expect it to be well answered so long as even our higher engineering offices are so much dependent upon the pleasure of politicians and will play to them, and with them. The voters must be enlightened and aroused, for as has been well said, "The people get about as good government as they desire and deserve." Ami Rite.

ORGANIZATION AS INFLUENCED BY PLANT OF CONCRETING GANGS FOR ROAD CONSTRUCTION.*

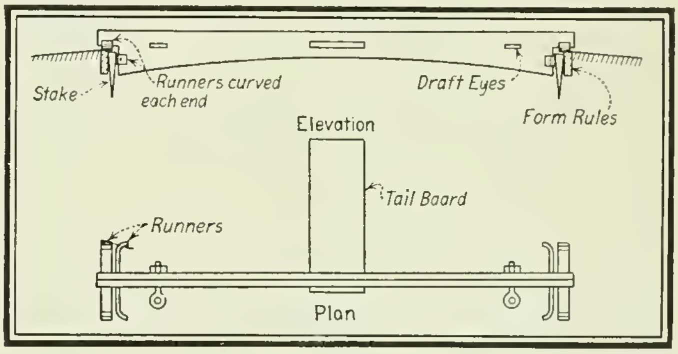
By Halbert P. Gillette.

The organization of gangs for concrete road construction can not be very well discussed apart from some discussion of the tools and appliances used in construction. Preliminary to any careful consideration of the details of the subject must come a general study of the co-ordination of the various gangs in such a manner as to reduce delays to a minimum.

The greatest single source of delay is usually an inadequate supply of materials for the mixer gang. This is apt to occur whether the road builder crushes and screens his own aggregates or whether he buys them delivered on cars. In the latter case, cars are apt to arrive in considerable numbers when they are not wanted, followed by failure to arrive at all when wanted. To reduce such irregularity of supply it is usually wise to detail one man to the task of "camping" at the source of supply. He can then see to it that the rock and sand manufacturers live up to their contracts as far as possible, also that the railroad supplies cars when needed and in advance of the need. Such a dispatcher will earn his salary time and again over.

If the stone and sand are furnished by the road builder himself, the delays that occur in the supply were in times past usually attributable to breakdowns of the crusher and elevator. But nowadays when motor trucks are so extensively used for hauling, we have another class of machinery also subject to disorder. There are four classes of machines used on large concrete road jobs: (1) Quarry and crushing plant; (2) Motor trucks, and (3) Pumping plant, (4) Mixer. Let any one of the first three "go wrong" and the last named, the mixer, may be forced to close down. Therefore it is of prime importance so to conduct the work as to have a large supply of materials delivered along the road in advance of the mixer. It is also a good plan to have a duplicate pump at hand for emergency, so that the water supply can be assured. Of the pumping plant we shall speak more at length later. It is essential to point out that since the entire organization of the men depends upon the plant, and since a complete road-building plant is by no means a simple affair, it is almost necessary to employ a very skilled and resourceful mechanic. In this connection we may add, the blacksmith shop should be provided not only with all the ordinary tools, with a good supply of iron, steel, bolts, etc., but with some of the commonly needed machine shop tools, such as a lathe and a drill press. An inadequate blacksmith outfit is economically fatal.

The stone and sand may be dumped alongside the road or directly upon the prepared subgrade, but in either case fully a mile of subgrade should ordinarily be kept prepared ahead of the mixer. If materials are haulod in motor trucks, it is usually impracticable to dump anywhere except directly on the prepared subgrade; and this is particularly true where the graded roadbed is narrow or where the earth at the sides is soft.



Grading Templet for Subgrading for Concrete Roads.

The subgrade for a concrete road must be very accurately graded. We shall describe a method in common use in California, and a "grading templet" devised by Mr. W. A. Gillette for subgrade leveling. The subgrade is first roughly graded with a road machine and left about 1 to 1½ in. higher than its final grade is to be. Then the "rules," or side forms, are placed and nailed to stakes driven on the "inside" of the rules. The earth for the "shoulders" is packed against the rules on the "outside." The "rules" are usually 2x4-in. stuff for a 4-in. concrete road, and 2x6 in. for a 5 or 6-in. road. There should be provided enough rules for two miles of road. Moreover, it may be remarked, these rules do not have a long life, for after they are removed in a wet condition they warp, often so badly as to be unfit for use. Some road engineers advocate leaving the "rules" permanently in place to protect the edges of the concrete after the earth shoulders settle.

Having set the rules, a road machine or grader is used to pare down the subgrade till it is about ¾ to 1 in. above grade, throwing the surplus dirt to the center. This excess earth is then removed with a two-mule "fresno scraper," which is easily tilted back by its long handle so it will ride up over the "rules." Then the subgrade is wet down and rolled lightly.

The next step is to scarify the subgrade, using a gang-rooter plow drawn by a steam or gasoline roller, to a depth of about 2 in. If the soil is hard clay, a disk cultivator is then drawn over it by a team to pulverize the clods. Then the "grading templet," shown in Fig. 1, is laid upon the "rules," and a team of horses hitched to it. The driver stands on the "tailboard" of the templet, and two laborers, one at each end, stand on the templet to hold it down. The templet is set to leave the earth about ¾ in. (varying with the character of soil) higher than the final grade, for the roller will pack the earth down to grade. If there are any depressions in the subgrade that are not filled by the windrow of earth that is pushed ahead of the "grading templet," the team is stopped while earth is shoveled in from the shoulders or from the surplus in front of the templet. The subgrade is then sprinkled from the pipe line and thoroughly rolled.

---

*Prepared as a part of the report on Concreting Gang Organization by a Special Committee of the National Conference on Concrete Road Building.

This careful preparation of subgrade is essential if there is to be a uniform thickness of the concrete, and no waste of materials. Few contractors at first realize the importance of such careful grading. It is no unusual thing for them to find that their finished concrete is ½ to 1½ ins. thicker than called for by the specifications, or else that it is so thin in spots that long stretches are condemned by the engineers.

To avoid the latter contingency a "checking templet" is used directly in front of the mixer. Such a templet is usually constructed with nails, 3 in. apart, projecting 1 in. from the bottom, so that a small rock will not raise the templet. If the subgrade has not been carefully prepared as described, the "checking templet" will disclose humps and hollows. The removal of a hump directly in front of the mixer will, moreover, delay the mixer. Hollows can not be filled and rolled or compacted without removing the sand and gravel, likewise causing delays.

In 3 or 4 hours with the "grading templet" more work can be done on a clay subgrade than by 12 men in a day with picks and shovels, and the templet will do better work. In sand, of course, the templet works much faster than in clay.

Attention should be called particularly to the side "shoes" or runners in Fig. 1, for they are essential to avoid knocking out the stakes.

Upon the finished subgrade the stone (or gravel) may now be dumped, and it should be dumped in piles at uniform intervals. Never leave the spacing of the piles to the teamsters or truck drivers. Assign to this work a careful man who is given authority to discharge any driver who fails to dump a load exactly as instructed. This man is given instructions as to the exact spacing of the loads, and loads should be occasionally measured to see that they are kept almost uniform in size.

The loads of stone are to be dumped on one side, and the loads of sand on the other side, between the "rules."

If the hauling is done with motor trucks, the trucks are backed in, for otherwise they would be stalled by the piles of stone and sand. Trailers can not be very well used where the road is narrow. The commonest mistake is to use trucks of large capacity. A 3-ton truck is preferable to a 5-ton truck on most road work. Indeed, if the road is rough and particularly if parts of it are through soft ground, it is wise to haul even less than 3 tons with a light truck, for not only do heavy loads on such roads put breaking strains on the machine, but the roads soon become so cut up as to be impassable.

Where wagons are used, the best practice is to haul with two 2-yd. wagons, one as a trailer, pulled by five head of stock, three in the lead.

The cement may be delivered with a light motor car from the stock tent or house to the mixer. A load of 8 or 10 bags can thus be hauled at low cost, and the car can be turned out onto the soft shoulders or sides of the road almost any place.

We come now to the actual mixing of the concrete. A mixer of ½ cu. yd. capacity is usually used, but a few road builders prefer a ¾-cu. yd. mixer. The materials are wheeled to the loading hopper of the mixer, and the concrete is delivered through a chute directly into the road. A good gang arrangement is as follows:

Mixer operator, finisher, foreman, two templetmen, one chuteman, one man to help chuteman place material, one man dumping cement in hopper, one man loading and wheeling sand to the mixer, four men loading and wheeling (alternately, two wheelbarrows), rock to mixer. Often two men are kept busy making small earth dams or "checks" to hold the water upon the finished concrete, and they attend to the watering. One man may be necessary to attend watering the concrete from a pipe line, providing "checks" are not used. One man is usually kept busy at night wetting the subgrade from the pipe line.

One team and driver and extra man are necessary to take up rules or forms and haul them ahead, and to gather up empty sacks, and general roustabout work.

The soft concrete is first leveled or "struck" with a light template made of 2-in. surfaced board that can be easily handled by two men. Having "struck" the concrete, a heavy template is used to complete the beveling and to tamp the concrete, which is then smoothed off by the finisher.

Mechanical concrete tampers have been devised, but on the whole are not satisfactory, because they bring too much mortar to the top and drive the coarse aggregate below the wearing surface.

A mixer gang such as the above can readily mix and place 140 cu. yd. in 8 hr. if there are no delays, or 750 lin. ft. of road 4 in. thick by 15 ft. wide. But such an output can not be counted on as an average. Delays commonly reduce the average output to 1 to 2 miles of such road per month. The best record of which we have knowledge is 3 miles per month.

When a serious delay occurs the mixer gang may be used to finish subgrade, but their work on subgrade will be very unsatisfactory as to output. Whether it is because they resent being changed from mixing to grading or whether any change whatever causes a fall in efficiency, certain it is that a mixer gang is of very little use on anything but mixing work. Some road builders have found it a good plan to use the mixer gang to shovel dirt from the shoulders onto the fresh concrete, spending about an hour at this every morning. This gives the crusher an added hour's work in which to keep ahead of the mixer. It also gives the mixer operator an hour in which to go over his machine and get everything in perfect order.

We have spoken of the water supply. Usually inadequate provision is made for this important feature of concrete road work. It rarely pays to haul water in tanks, even though the haul is very short. Water is needed not only for mixing the concrete, but for wetting the subgrade and for keeping the concrete surface wet for a week or more after concrete is laid. There are often places where it would be impossible to get near enough to the fresh concrete to wet it from a tank. A pipe line is most economical and it is claimed by experienced contractors that two parallel pipe lines should be used, supplied by a high pressure pump. Because when a gate or hydrant is opened between the mixer and the pump it often takes the water away from the mixer, thereby causing a delay in mixing. One line should be used for the mixer only, the other for concrete wetting, camp supply, etc.

When taking water from a well it is necessary to use a pump-jack or lifting pump with a capacity of 60 to 80 gal. per minute, requiring about 4-HP. engine. These pumps are constructed with gears which operate an eccentric which moves the pump-jack and rod up and down, driving the piston submerged in the water. A double action piston is the best. The water is pumped into a 1,000 to 2,000-gal. storage tank, which supplies the high pressure pump.

If water is taken from a stream, use a small centrifugal pump with about 4-HP. engine, and pump into a tank as above stated, so that the sand will settle and thereby prevent seriously damaging the high pressure pump pistons and valves. Slight scoring of the pistons often renders a high pressure pump useless until new pistons are installed.

The mistake is often made in getting a cheaply made high pressure pump or one that is too small. The theoretical capacity and size of a contractor's pump deduced from engineering formulas is almost invariably too small.

A satisfactory high-pressure pump for water supply on road work is a 4x6-in., 350-lb. pressure. This pump will deliver 50-gal. per minute through a 2-in. line five miles long, with a 250-ft. lift, and farther, of course, if the lift is less. It will be necessary to operate a pump with 50-gal. per minute capacity, 12 to 14 hours, in order to supply the mixer and wet the concrete during the day and wet the subgrade after the mixer shuts down, each day.

In installing this pump run the pipe from the relief valve back into the storage tank.

After 2-in. pipe has been strung along the road, four men will lay 1,000 to 1,500 ft. a day of new pipe, and 600 to 800 ft. of used pipe, the battered threads increasing the time. Flange unions and gate valves should be put in about every 500 ft. and 2-in. T's with 1-in. outlet should be put in about every 100 ft.

Obviously there are more possible organizations of concrete road gangs than there are combinations of machines and devices used in concrete road work. To attempt to describe every combination would involve reviewing all the literature that has been written on concrete road building. Since this is out of the question in a report of this character, we have chosen a somewhat typical combination in concrete road building on a large scale in California, all the details of which are familiar to your committee. In addition we have given eight other examples of gang organization reported to members of the committee by those who have employed them successfully. These examples may serve as a basis of discussion as to departure therefrom under varying conditions. Obviously a plant and organization to build only a mile or two of road at a stretch will differ from one to be used in building 5 or 10 miles.

In this connection it may be well to emphasize the economic importance of letting contracts for concrete road work in rather large stretches. Including a grading outfit, a concrete road contractor may have $25,000 invested in one plant, exclusive of motor trucks, but inclusive of a small crushing and screening plant. It is highly important, therefore, that he be able to count upon fairly continuous work for his plant. Hence, if practicable, each contract should be large enough to keep the plant busy one entire road-building season. Contracts should be let as early in the year as possible.

It is a lamentable fact that the cost of concrete road work is almost invariably underestimated by those who have not previously done precisely that sort of work under precisely the same specifications and conditions. Each year brings its new crop of "fool contractors" into the market, ready to take work at prices that result in loss. At least a partial preventive of this unfortunate condition consists in attaching to each bidding sheet the road engineer's detail estimate of the cost of the projected road. A further preventive is the publication of actual costs under varying conditions.

METHODS USED IN RE-LEVELING A 200,000-CU. FT. GAS HOLDER.*

The following is a description of the methods used in leveling a 200,000-cu. ft. gas holder which, due to the settlement of its foundation ,had become so distorted as to jeopardize its safety. The holder is the property of the Connecticut Power Co., and is located on the west bank of the Thames River, approximately 75 ft. from the water's edge and adjacent to the generator house. It is of the steel tank type, with two lifts and was erected in 1905. The tank has a diameter of 75 ft. and a height of 20 ft. 9 in., the two lifts having diameters of 70 ft. 6 in. and 70 ft., respectively, and heights of 25 ft. 9 in. The total weight of metal is about 188 tons, and the total weight of the structure, with the tank filled with water, is 3,710 tons. The latter weight, based on the tank diameter of 75 ft., represents a foundation pressure of 1,680 lb. per square foot under normal operating conditions.

In constructing the original foundation of the holder about 500 wood piles 18 to 20 ft. in length were used. Around the outer circumference of the foundation there were driven four concentric rows of piles spaced 18 in. on centers, while within the inner row the piles were driven at the apices of equilateral triangles, the sides of which were about 3 ft. long. The tops of the piles were driven to approximately the same grade, and a 12-in. layer of concrete, topped with a 2-in. layer of dry grout, was then placed on the piles. This foundation was considered adequate to carry the load, although it proved not to be sufficient.

Since September, 1912, when Stone & Webster became interested in the property levels were taken at regular intervals. During the period September 14, 1912-January 14, 1916, the levels showed the difference in elevation between the extreme high and low points of the curb angle to be 8¼, the side nearest the river showing the greatest settlement. The readings also showed that not only was the entire holder slowly sinking at an average rate of approximately ¾ in. per year, but that the low side was sinking at considerably greater rate than the high side. For example, from September, 1912, to September, 1913, the low side showed an increased settlement over the high side of ¼ in.; from September, 1913, to September, 1914, the increased settlement was ⅜ in.; while from September, 1914, to February, 1915, the difference in settlement was ¼ in.

To prevent permanent injury to the holder re-level the entire holder, although it was evident that it would be impossible to prevent further settlement. With the data at hand it was estimated that, at the same rate of settlement, it would require about 30 years for the holder again to become unsafe.

When definite action was decided upon, in February, 1915, the difference in elevation between the high and low point of the curb angle was 9⅛ in. It was decided to start the work of re-leveling as soon as weather conditions would permit, and the original builder of the holder, the Bartlett-Hayward Company, was asked to recommend a plan of action. The result was that this company was placed in charge of the engineering details of the work and supplied all special tools and equipment, while the actual field work was to be done under the supervision of the local operating department.

Before the work of leveling was started test borings were made at three points spaced approximately 120° around the holder. These borings showed that fairly good bearing earth was reached at an average depth of 28 ft., while a first class bearing was not obtained until a depth of 35 ft. was reached. As none of the piles in the foundation are over 25 ft. long, few, if any of them, were driven to refusal or to a sufficient depth to assure satisfactory bearing. These borings also showed that the ground where the settlement of the holder was greatest was the poorest for supporting a heavy load.

After only one sheet was left on the top lift of the holder the inlet and outlet valves were closed and the drips sealed with water. The remainder of the gas was then allowed to escape through the crown through two ¾-in. holes in the manhole plates. After the holder had grounded, evidence of its distortion was apparent from the position of the inlet and outlet standpipes, which, instead of rising through the manhole turrets, struck on the edgs of these and subjected the crown to severe strains.

For emptying the tank of about 1,000,000 gal. of water a 6-in. siphon of flanged pipe and fittings was used. In addition, six ¾-in. rivets were cut out of the bottom curb angle, allowing the water also to escape here. The water was handled in this manner in about 36 hours. After all the water which could be removed by gravity had been run off the remainder, which contained considerable dirt in suspension, was removed in buckets lowered through the manholes. The tank bottom was then flushed out with a fire hose. The entire operation of emptying and cleaning the tank required about four days.

---

*From paper by A. R. Schiller before New England Association of Gas Engineers.

With the tank empty work was started cutting holes in the concrete foundation for the jacks. These holes, 20 in number, were located under the landing beams. There are 24 landing beams in the holder, but only 20 were under-cut for jacks, as it was not considered necessary to raise the holder on the high side. The jacking holes were 24 in. wide circumferentially and extended 3 ft. under the tank. For approximately one-third of this width the under-cut was 10½ in. deep to take the jacks, and for the remainder only 6 in. deep for inserting oak blocking timbers topped by oak wedges to follow up the jacks and to relieve them of the weight of the holder.

As the south side of the holder is only 3 ft. from the generator house wall it was impossible to use jacks under the landing beams at two points, and holes were therefore cut in the tank bottom. By means of jacks placed on the concrete foundation the weight of the lifts was taken off of the tank bottom at these two points. In this way it was possible to get along with follow-up wedges alone on the outside.

From inside the tank 7-in. diameter holes were cut in the bottom plates for screw jacks with which to raise the bottom. These holes were flanked on two opposite sides by short pieces of 3-in. angles bolted to the tank bottom to afford a means of attaching the jacks to the tank bottom. In all twelve holes were cut at various places around the tank where settlement required the bottom to be raised. As soon as the holes within and without the tank had been cut the work of jacking was commenced the outside work being started first. The procedure used was as follows:

Twelve short 2x10-in., 10-ton jacks were placed in the holes cut around the holder, these jacks being set to one side of the landing beams in order that the blocking wedges carrying the load were directly under the beams. The jacks were then manned and the tank gradually raised from its foundation. During the raising the wedges were kept driven home so that the weight of the holder was carried by the wedges and blocking. Levels were taken at frequent intervals until the former low points of the tank showed an elevation above the previous high points of approximately 0.9 in. A wooden form, with pockets to protect the jacks and blocking, was then built entirely around the tank bottom, and into this form was poured and rammed a heavy grout of 1:3:4 concrete. This was worked under the tank bottom for a distance of about 6 ft., the grout being of sufficient thickness to fill the space between the foundation and the tank bottom. The maximum thickness of the grout was 9½ in., and its average thickness around the entire holder was less than 5 in. After the grout had set the jacks and blocking were removed and the spaces filled with a similar grout.

After the greater part of the external jacking had been completed, but before the concrete was poured, work was started inside the holder, re-leveling the tank bottom. The first step in this work was to raise the center pier by cutting a hole in the tank bottom, through which a jack was placed on the concrete foundation and applied to cross braces bolted to the lattice of the center pier, thus raising the pier. Grout was then worked under the bottom plates so as to fill entirely the cavity formed.

The tank bottom was next leveled by means of four raising screws whose bearing ends rested on the concrete foundation through holes cut in the bottom plates. These four screws were moved from one to another of the twelve holes which had been cut in the bottom until the desired condition of level was obtained. The method used in placing the grout underneath the bottom was as follows:

Holes 5 in. in diameter were cut through the bottom plates and an extremely wet grout poured through them. At first a mixture consisting of 2 parts cement and 1 part screened sand was tried, but it did not flow a sufficient distance under the tank from the holes. For pouring the grout into the holes a flange tapped 2 in. was bolted over the hole, and into this was screwed a 3½-ft. length of pipe carrying a galvanized iron funnel. The grout was then poured into the funnel and thus forced under the bottom plates. In doing this work it was found necessary to keep the grout agitated up to the instant it was poured.

For grouting both inside and outside the tank approximately 800 bags of cement were used, 50 on the outside and 750 on the inside. The operations of jacking and grouting required about six weeks.

After re-leveling it was found that even though the standpipes cleared the edge of the holder crown and entered the recesses they were still far from centering therein. The standpipes were centered by inserting between the flanges wedge-shaped cast iron fillers of the proper taper.

After making several repairs and replacements of a minor character the holder was re-caulked and re-pointed and returned to service.

Levels taken after the tank had been filled with water showed an average settlement around the entire holder of approximately ¼ in. over those taken a few days previous to filling the tank, the settlement being uniform. Levels taken six months after the holder was returned to service showed a total average settlement of 0.6 in., with an increased settlement of the point nearest the river over that on the opposite side of the holder of 0.3 in., which corresponds very closely with the difference in settlement before the re-leveling operations.

After the holder had been in service a short time a survey of the tank and guides was made, which showed that the superstructure had suffered no derangement due to the re-leveling work. The guide columns proved to be nearly plumb, both tangentially and radially, within the limits allowed in new work of this kind. Upon re-adjusting the goose neck rollers, the rising and falling of the holder were not accompanied by the excessive side strain on the goose necks that existed previous to re-leveling.

The time required for the entire work, from service to returning the holder to service, was almost 2½ months, with the following force: A visiting engineer from the makers of the holder, who made regular inspections during the work; 1 foreman, 2 mechanics and 8 laborers. The total cost of the work, including miscellaneous repairs, recaulking and repainting, was $4,100.

THE EASTON-ALLENTOWN CONCRETE ROAD: AN EXCEPTIONAL EXAMPLE OF MODERN ROAD ENGINEERING.*

By Wm. D. Uhler, Chief Engineer, Pennsylvania State Highway Department.

The Easton-Allentown road, known as Pennsylvania State Highway Route No. 159, extends from Allentown, Pa., through Bethlehem, Pa., to Easton. The road is important; it joins three large cities and is largely traveled. Its construction of concrete was decided by residents along the route who agreed to contribute the necessary cement and broken stone provided a one-course concrete road would be constructed by the State Highway Department. In agreeing to these terms the Department officials decided to do the work by force account, to employ the most modern and economical plant and construction methods, and, in short, to make the road a criterion and example of high class modern concrete road engineering.

In the construction of this highway, which is not yet completed, especial attention is and has been paid to every engineering detail, starting with the subgrading and drainage, thorough rolling of subgrade before placing materials, proper grading of aggregates, the exact proportioning of materials and the amount of water used. Other details closely watched are the timing of the mix, laying of the concrete, striking off and curing of the pavement.

After the subgrade is finished accurately, drained and rolled, the forms are placed, which consist of 6-in. channels in 12-ft. lengths, held in place by steel pins; particular care being taken to have the alignment and grade of these forms accurate. The steel forms are being used both for economy and on account of the ease with which they can be handled.

---

*Paper presented at the Pittsburgh meeting of the American Road Builders' Association.

To eliminate the re-handling of materials, a system was devised for the proper distribution of the aggregate and cement. On this work all materials have been brought to the point of use on trolley cars, advantage being taken of the fact that the car tracks paralleled the full length of the road, making it by far the most economical way of handling the materials. This method of delivery proved advantageous for unloading sand and stone at measured intervals. Portable canvas sheds, holding 90 sacks each, used for the storage of the cement, were placed at measured distances along the route, and as emptied were moved ahead.

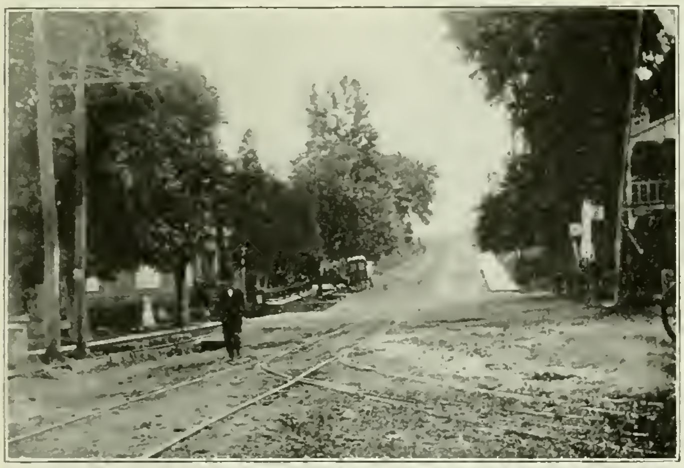


Fig. 1. Original Condition of Easton-Allentown Road.

In proportioning the batches, the sand and stone were handled in specially devised wheelbarrows, of 3 cu. ft. capacity, to insure accurate measuring, and when loaded these barrows were struck off with a shovel. The same care has been given with reference to the amount of water used in each batch, just enough being put in to secure a plastic mixture which would not quite level down in the bucket or when dumped.

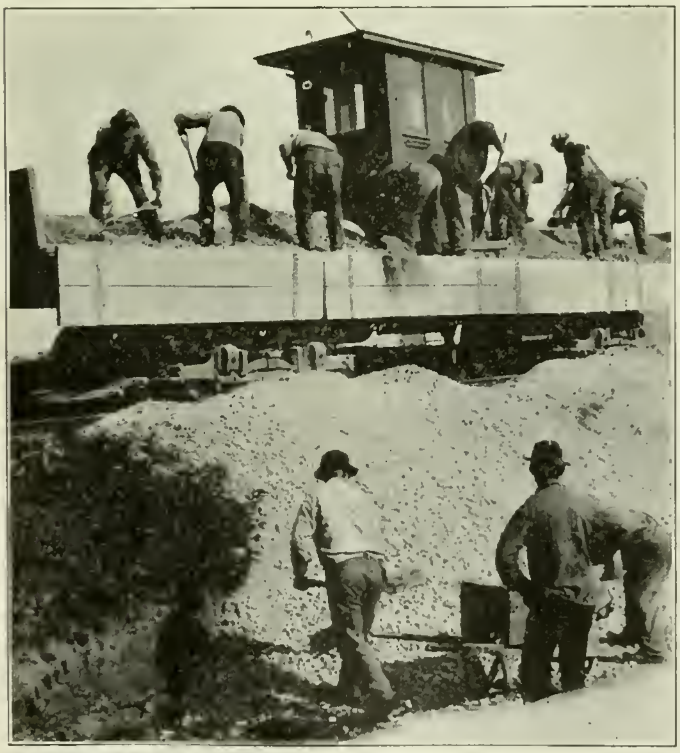


Fig. 2. Unloading Stone From Trolley Car.

Every batch of concrete is mixed for 1½ minutes; the reason for this being that a number of experiments, made during the progress of the work, indicated that the greatest strength, commensurate with ecnomy in cost of mixing, is obtained from a mix of this timing. The experiments which resulted in this conclusion were as follows:

One-half minute mix, 9 revolutions, 8 day test, 1,400 lb. per sq. in.
One minute mix, 17 revolutions, 8 day test, 1,587 lb. per sq. in.
One and one-half minute mix, 26 revolutions, 8 day test, 1,924 lb. per sq. in.
Two minute mix, 35 revolutions, 8 day test, 1,661 lb. per sq. in.
Three minute mix, 51 revolutions, 8 day test, 1,675 lb. per sq. in.

This shows that if these results are plotted, the curve would break between the one and one-half and the two-minute periods. If the accuracy of the results on the one and one-half minute mix be questioned, and this figure assumed to lie between 1,587 and 1,661, the results plotted so as to form a curve will show that the rate of increase in strength decreases with increase in the time of mix, and the increase obtained from the two and three-minute periods is scarcely worth the additional time and cost involved.

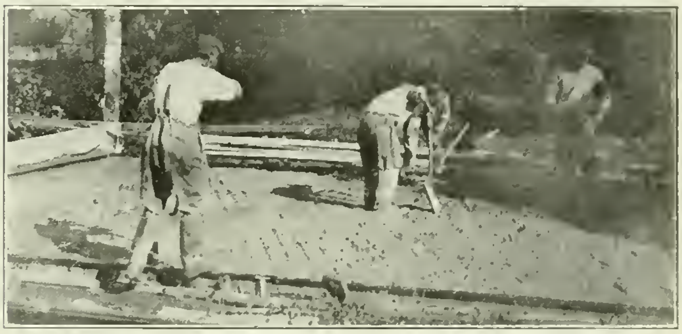


Fig. 3. Placing Concrete on Sheet Metal Reinforcement.

Another feature that has been brought out in connection with this work is the great variation in strength of 6-in. cubes of the regular mix, made up daily during the progress of the work, and set aside for testing at periods of seven, fourteen and twenty-eight days and six months.

The seven-day compression test runs from 1,065 to 3,633. The fourteen-day test, from 1,572 to 4,212. The twenty-eight day test, from 2,562 to 5,361. As yet, no six-month breaks have been made.

These wide variations in strength values may be due to a combination of several causes, including variations in the quality of the cement and mineral aggregates; difference in storage temperature (some of the specimens having been made up during warm weather and some during very cool weather); possible slight differences in the mix, and differences in the molding and compacting of the specimens; and finally, of course, the unavoidable experimental variations in making and breaking the specimens.

Since every one of these factors, except the last named, enter into the actual construction work, the importance of systematic testing of the cement used, examination of the sand and stone (particularly with reference to grading), and strict adherence to uniform, approved methods of mixing, placing, compacting, and curing the concrete in the pavement, are forcibly demonstrated by the range in these daily strength values.

Before placing the concrete, the subgrade is thoroughly sprinkled, after which the concrete, mixed in the proportions of 1:2:3, is placed to a depth of 6 in. at the side and 8 in. in the center, and then struck off with strike boards. A heavy strike board is used first, followed by a lighter one, which results in the compacting of the concrete and the elimination of waves or rolls in the surface. The striking off always should be done in the same direction as the progress of the work. When the strike board proceeds to within 3 ft. of the joints, it is lifted and placed alongside of the joint filler, or installing bar, and then worked away from the joint. This avoids the danger of piling up material around the joint or pushing the joint out of perpendicular. Joints which are not perpendicular may cause uneveness due to one slab rising on another. Proper striking off puts the surface in condition to be finished with the least amount of labor, as well as making it possible to secure an even, true and dense pavement.

After the water has disappeared, the surface is floated with a wooden float. Too frequently it is the case that the floating is done prematurely and this has a tendency to bring the fine light particles to the surface, which offers little, if any, resistance to abrasion.

Joints ¼ in. wide are provided at intervals of from 36 to 40 ft. These are filled with a prepared bituminous material ¼ in thick and 9 in. wide, placed in accordance with the standard practice of today. The concrete on either side of the joint is finished with a split float, which gives a surface of even height on both sides of the joint and overcomes to a great extent the so-prevalent rough riding joints. The edges of the joints are then rounded with a 3/16-in. edger to prevent the spalling or breaking of the edges. The bituminous joint material is trimmed off about 1 in. above the finished surface, which permits traffic to beat down the projecting filler, thus forming a protection to the edges.

The sides of the slab are then rounded with a ¾-in. edging tool, which not only adds to the appearance of the work, but serves to protect the sides and prevents chipping by traffic turning on and off the road.

There is a vast difference of opinion as to the advisability of using protection plates at the joints. Experience leads me to believe that if proper care is taken in the maintenance of the unprotected joints, built as outlined above, far more satisfactory and economical results will be attained than by the use of steel joints, especially if there is any difference in the rate of wear of the concrete and the steel in the joints. Only a thousand feet of this road has been constructed with steel protection joints, and up to the present time no advantage in this method of protection is noticeable.

The road in question, although of 6-in. and 8-in. con-

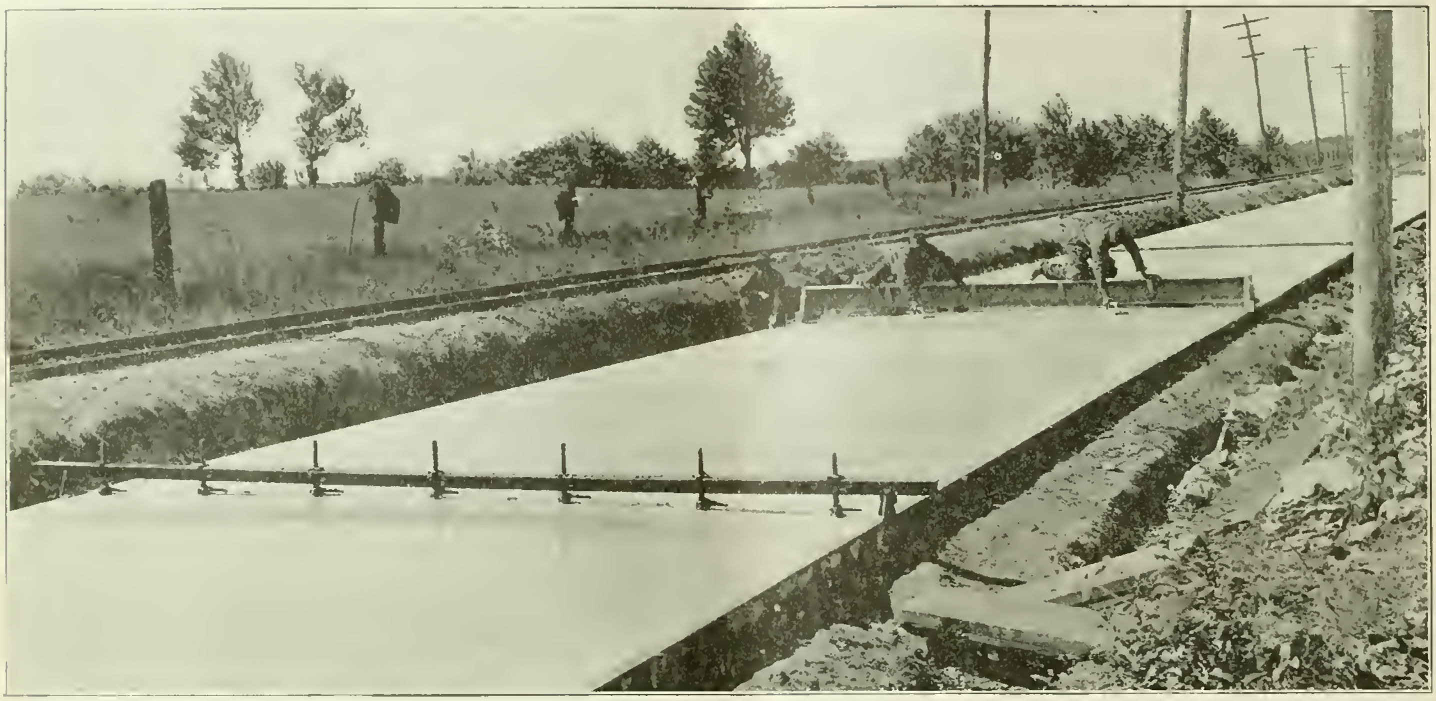


Fig. 4.—Concrete in Place Showing Expansion Joint and Hand Finishing.

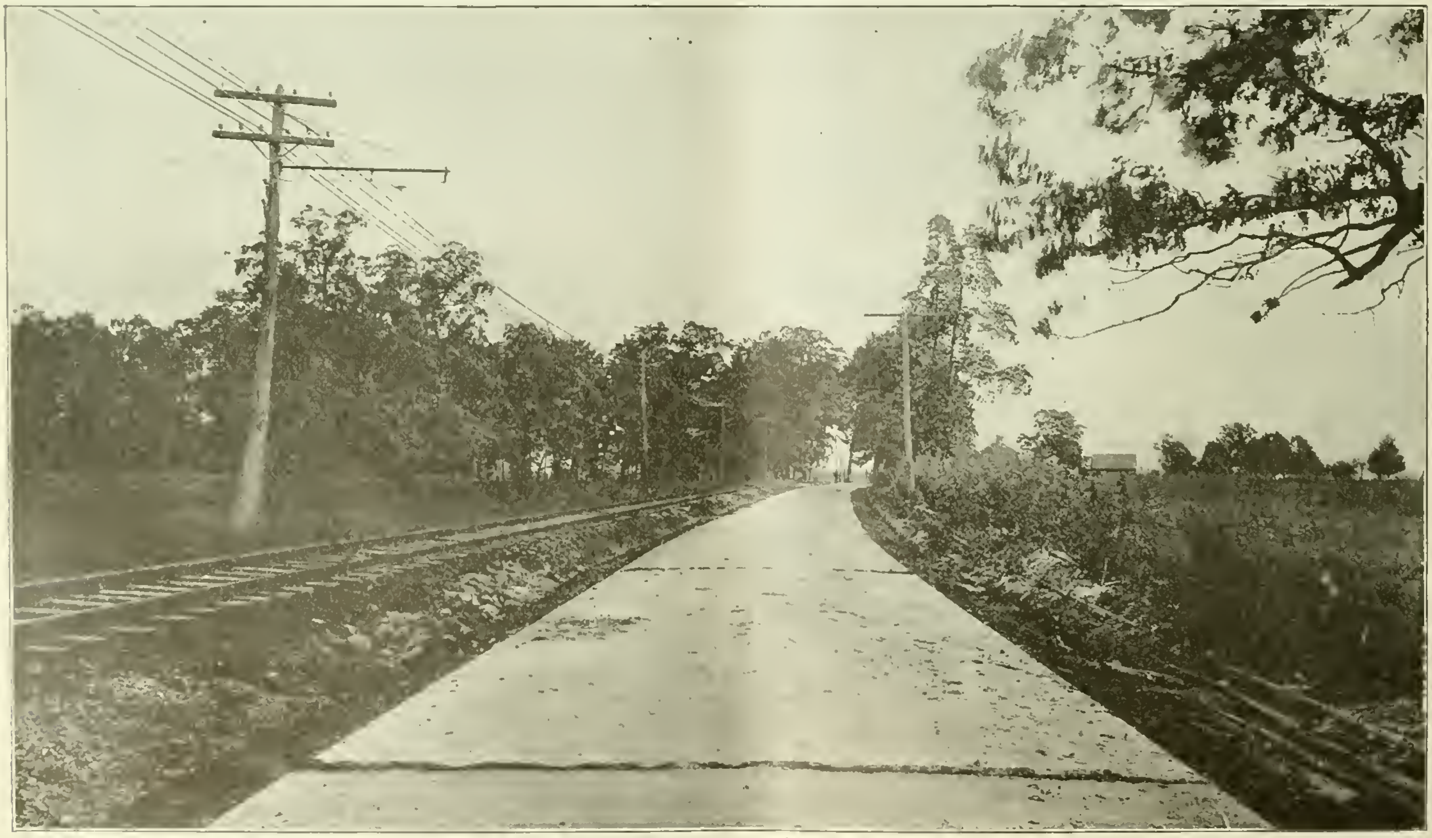


Fig. 5. Finished Road Prior to Trimming Joints.

struction, is reinforced also with a light metal fabric, which is shipped to the job in sheets 5 ft. in width, and 6 and 10 ft. in length. This is placed with longitudinal joints staggered and with a lap of 4-in. crosswise and 12-in. longitudinally. Of course, it would be preferable if sheets could be obtained the full width of the roadway. Reinforcing shipped in sheets, in my opinion, is more satisfactory because it is easier to handle and can be installed with less trouble, while with the rolls there is bound to be more displacement of the concrete when the workmen endeavor to force it into place.

This metal reinforcement is placed 2 in. below the top of the slab. It reduces the number and size of the cracks and is designed also to overcome longitudinal cracks which may occur because of the settlement of the shoulders.

Throughout the West the general practice is to build concrete roads, without reinforcement, 6 in. at the side and 8 in. in the center. Personally, I believe that far better results can be obtained at the same cost, and under some conditions at less cost, by the construction of 5-in. and 7-in. concrete roads with light metal fabric reinforcement.

In order to secure the maximum strength and wearing qualities, special attention is given to the curing and protection of the concrete pavement. During hot and windy weather the fresh concrete is covered with canvas as soon as possible after floating. To keep the canvas off the fresh concrete, portable forms were constructed, which could be taken up and set along the edges of the pavement, projecting about 12 in. above the pavement on which the canvas covering, which was on two rollers, was easily unrolled. This method of handling the canvas covering proved very satisfactory. After the concrete had had sufficient time to harden the canvas was removed, and the pavement covered with from 2 to 3 in. of earth and kept wet from 10 to 14 days. The pending method of curing, employed by the Highway Department of California, permits the flooding of the pavement and is more economical and far more satisfactory, but due to the character of our soils it is not practicable in this section of the country.

At the expiration of the fourteen-day limit, the earth covering was removed and the road thrown open to traffic.

Of this twelve miles just described, a section about 3¼ miles in length was completed last season. An inspection made recently shows that thus far only two slight cracks have developed in the pavement.

Other experiments will be made on this work during the coming season, with reference to the time and speed of mixing and also the water consistency.

In order to make a more complete study of the cause of cracks in concrete pavements, three lines of precise levels have been run taking elevations at each end of every slab, at each corner, and in the center. This should give us some valuable data, and in case longitudinal cracks occur, enable us to determine whether there has been a heaving, due to frost action, or a settlement of the shoulders.

CHARACTERISTICS REQUIRED OF CONCRETE TO RESIST ACTION OF SEA WATER.*

By W. Walters Pagon, Principal Assistant, Greiner & Whitman, Consulting Engineers, Baltimore, Md.

In order to construct concrete that will have the greatest resistive power against the action of sea water (and also probably of alkali waters) it must possess the following characteristics:

1. The addition of puzzolan in some form is widely practiced in Europe and appears to be theoretically correct. It has not been tried in America, to the author's knowledge, but is worth an exhaustive test. The amount should not be over one part for each part of cement, nor less than one-half part.

2. Waterproofing with substances that combine chemically with the free lime ought to be successful and is worth testing.

3. Between extreme high and low tides the concrete surfaces should be faced continuously, without joints, with about 3 in. of 1:1½ or 1:2 mortar, made with sand as specified below, well cured before coming in contact with the sea water. Facing must be placed simultaneously with the backing.

4. The cement should be low in lime and alumina and contain as little gypsum as possible.

5. Sand must be silicious, uniformly graded from fine to coarse, with not less than 50 per cent nor more than 70 per cent passing through a No. 20 sieve, and not more than 3 per cent passing a No. 100 sieve, and must have no organic matter coating the grains. It must be free from roots and easily disintegrated grains, such as feldspar, shells, limestone, mica, etc. It should be washed free from clay, and should show a tensile strength for 1:3 specimens not less than the following percentages of the strength of Standard Ottawa sand of the same consistency, using the brand of cement that is to be used on the work:

Age.	Percentage strength.
1 day	85
3 days	90
7 days	95
28 days	100

6. Where concrete must be exposed to sea water without mortar facing gravel should not be used. Broken stone should be hard, durable trap, granite or other dense, hard, insoluble stone. It should not exceed ¾ in. in size and should be free from crusher dust, sand, dirt, organic matter or other foreign substances. Mixture should be 1:1½:3 or 1:2:4, or should be proportioned for maximum density.

7. Pure, fresh water should be used in sufficient quantity to permit the materials to be well puddled and spaded, so that no later surface treatment or patching will be required, but not sufficient to materially retard the setting of the cement. Care must be exercised, however, to prevent the formation of laitance or pockets of neat cement or very rich mortar.

8. Forms should be tight to prevent leakage of cement or, where concrete must be submerged immediately, to prevent contact with the sea water.

9. Facing should be reinforced with steel well covered with mortar and securely anchored to the backing.

10. No surface treatment should be given.

11. The work should be allowed to harden two weeks, if possible, before coming in contact with sea water. Two months is better.

12. Sea water work should never be done in cold weather, with temperature below 40 degrees F.

13. Where possible pre-cast, mortar faced blocks cured in damp sand for at least one month should be used. Facing should extend back at the joints to prevent saturation of the backing. The joints should be pointed with 1:1 mortar of coarse sand.

14. The most durable surface will be obtained if granite or other dense stone be used as facing. This should not be less than 6 inches thick, anchored back with wrought iron clamps, and pointed with 1:1 mortar of coarse sand and cement as noted above.

15. On mortar or concrete surfaces the growth of barnacles, moss, etc., will frequently afford protection.

All of the foregoing can be summarized into these statements:

Use materials that cannot be attacked by the sea water salts.

Mix these so as to obtain the maximum density.

Have no stones near surface of concrete but use mortar face 3 in. thick.

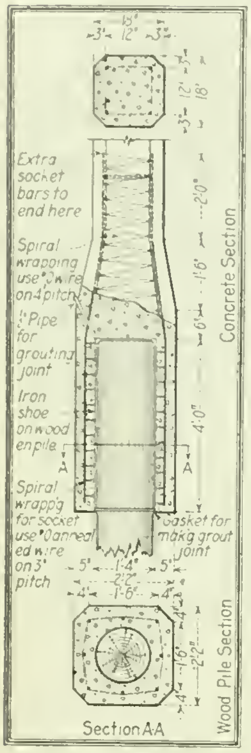
Opportunity for Young Engineers.—Within the next six weeks the Milwaukee Sewerage Commission will take on 12 young civil engineers for two years' service at $90 a month. The experience they will gain will be worth more than their salaries to them. They will act as inspectors on the construction of the sewage collection and disposal works.

---

*Extract from a report submitted to J. E. Greiner and printed in the Journal of the Engineers' Club of Baltimore.

Current Engineering Practice Briefly Recorded

PRECAST CONCRETE PILE WITH SOCKET BOTTOM FOR EXTENDING TIMBER PILES ABOVE WATER.

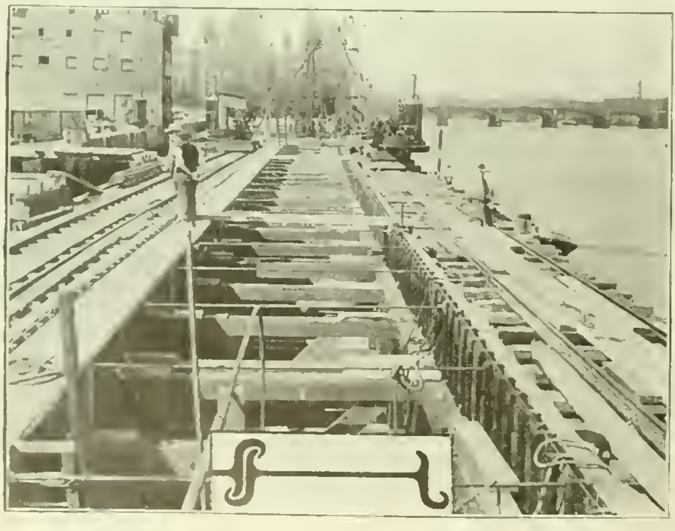

15"
3"
12"
3"
3"
12"
18"
3"
Extra socket bars to end here
Spiral wrapping use"0 wire on 4" pitch
½" Pipe for grouting joint
Iron shoe on wood en pile
A
A
Spiral wrapp'g for socket use "0 annealed wire on 3" pitch
Gasket for mak'g grout joint
2'0"
1'6"
6"
4'0"
Concrete Section
5"
1'4"
5"
2'2"
4"
1'6"
4"
4"
1'6"
2'2"
4"
Section A-A
Wood Pile Section

The combination pile shown by this sketch has been used in a number of marine works on the Pacific Coast and subjected to severe driving and breaking tests. The construction is designed for use where timber piles are subject to teredo attack or where extending above water there is danger of rot. In construction the timber pile is driven to part depth and then the precast concrete pile is socketed over its top. In placing the concrete pile, it is not at first closed completely down onto the wood pile, but is held up about 6 in. until the void space can be filled with grout. When grout filled the concrete pile is closed down and the grout forced into all spaces is permitted to harden. Then driving is resumed on top of the concrete extension and continued until the wood pile is below the water line or the mud line if teredo attack is feared. In tests the combination pile has withstood very heavy driving, and breaking tests have always ruptured the pile in the shaft and not in the joints. The inventor of this pile is K. D. MacLean of San Francisco, Cal.

A BRITISH EXAMPLE OF LARGE COFFERDAM CONSTRUCTION OF STEEL SHEET PILING.

Contributed by Frank C. Perkins, Buffalo, N. Y.

The accompanying illustration shows a cofferdam 210 ft. long and 13 ft. wide. This work, known as the "Thames Embankment Extension and Westminster Improvements at Millbank," has been carried out by the London County Council, and consists of removing a large number of old houses and wharves, street widening and extending the Victoria Tower Gardens to Lambeth Bridge by continuing the embankment wall. The engineers for the County Council adopted 15x5 in. section of "Universal Joist" steel sheet piling, weighing 43 lb. per foot. The piles for the front row were 44 ft. 6 in. long each in two pieces, the bottom lengths being 19 ft. 6 in. long, whilst the top lengths were 25 ft. long, these two lengths being joined together by fishplates riveted to the top length and bolted to the bottom length, the bolts having square necks, to suit square holes in the outside fishplates. The clutches, which were also in two pieces but not fishplated, were 18 ft. long in the bottom lengths and 26 ft. 6 in. in the top lengths, so as to add stiffness to the joints. The piles for the back row were 41 ft. long each, and these were in single lengths, whilst the piles for the ends were 42 ft. 6 in. long each.


Steel Sheet Pile Cofferdam, Thames Embankment, London.

The driving was carried out from a temporary stage by means of two 3,000 lb. single acting steam pile-driving plants of a special type, the two machines driving on an average eighteen piles per day, or equivalent to 11½ ft. of completed dam. No difficulty was experienced in closing, it being unnecessary to employ special piles for this purpose. As soon as the dam was closed the timber framing was put in, and pumping commenced and the excavation proceeded with. When the excavation was down to the required level the concrete was put in, this being done in sections. To prevent adhesion of the concrete to the back row of piling, which had to be withdrawn on completion of work, a light match-boarding was placed along the edges of the clutches.

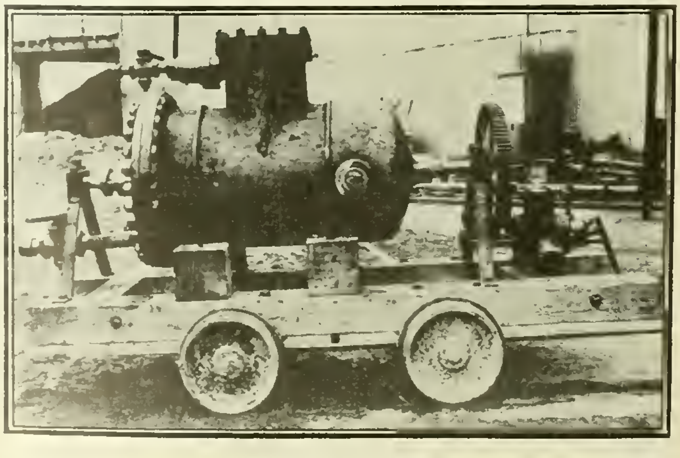
As soon as the concrete was up to the level of the fishplates, the nuts were removed and the bolts driven through and replaced by wooden plugs. As the wall was finished above high-water mark a stunt head was put in, formed of timber, and securely tied about 10 ft. from the end of the dam, the back row of piles then withdrawn and redriven ahead, whilst the top lengths in the front row were pulled and bolted up to a fresh set of bottom lengths, and again driven for the next section; the end was also drawn and redriven ahead to close the second dam. After this was completed the operation was again repeated on the third section, to finish the total length of wall required, which was 630 ft. long.

It is stated that the dam was practically water tight, a 5 in. Worthington pump, working intermittently, being quite sufficient to keep it dry, in fact a pump of much smaller capacity would have been ample.

GROUTING MACHINE FOR ASTORIA TUNNEL, NEW YORK CITY.

Contributed by J. Vipond Davies, Consulting Engineer, New York, N. Y.

The illustration shows the grouting machine employed in the Astoria Tunnel work. The following description of these machines occurs in the Proceedings of the American Society of Civil Engineers, Vol. XLI, No. 6, August, 1915, in connection with my paper written on the Astoria Tunnel:


Grout Mixer and Injector.

> The special machines for grouting with 500-lb. air pressure were designed and assembled at the tunnel works. The general arrange-

ment and capacity were identical with the riveted pans for 200-lb. air pressure, with the exception of some details designed to resist the higher pressure. The entire pan and the cover were made of cast steel, carefully annealed and tested, and having no joints other than that of the cover. The heads were made in convex form; one end was cast in one piece with the body, and the other was a cast steel removable cover with male and female bolted flanged joints. In operation these pans were very reliable, and, when required, one pan was operated 25 hours without a stop, and discharged 4,500 bags of cement at pressures varying from 350 to 500 lb. Extra heavy 2-in. screwed pipe was used for the transmission of the high-pressure air from the engine-room to the heading, with the exception of the first 600 ft., where extra heavy 4-in. pipe was used to give greater storage capacity. Special 1-in. hose was used to make the connection between the air line and the grout pan. This was a 6-ply rubber and canvas hose, with a marline woven cover, wound with 3/16-in., half round, steel wire, 4/10-in. pitch. Knox standard couplings were fitted to each end. A special 2-in. grout hose was used, this also being of 6-ply rubber and canvas, wound with 3/16-in., half round wire, ½-in. pitch.

The machines consisted of a wooden frame mounted on wheels to run on the mucking tracks, and built as low as possible. On this frame is mounted a drum, built of cast-steel, about 21 in. internal diameter by 36-in. long. One end of this drum is convex and fitted in the center with a stuffing-box. The other end of the drum is flanged to which a detachable cover is fitted, and in the center of the cover there is also a stuffing-box. In the top of the drum is a trunk rectangular frame 10½x10½ in., fitted with a flap door, opening inwards, through which cement and water are poured into the inside of the drum. A shaft passes through the entire length of the drum and through the stuffing boxes, and this shaft is fitted with paddles operating inside of the drum, for stirring up the mass of cement and water.

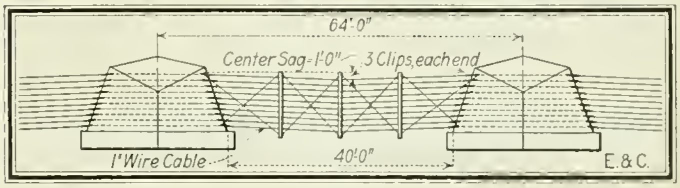
The Ingersoll-Rand three-cylinder engines were used for rotating the paddles. These are air engines operating with the air pressure which was used for running the drills, or for other purposes, in the tunnel.

The inlet connection for compressed air is fitted to the projecting trunk with the use of a plug or other cock which will operate rapidly. The discharge from the pan is attached to the end cover fitted on the flanged end of the drum.

Operation is very simple. The air turned on to the three-cylinder air engine rotates the paddles; sufficient water for four or five bags of cement at a time is turned into the drum—the paddles continually rotating; the bags of cement are then poured into the flap-door on the top of the trunk. This door is then lifted to its joint and air pressure admitted to the inside of the drum, and after admission of the air the mixing continues for one or two minutes to make a thoroughly mixed grout out of the water and cement. As soon as the gang is ready to apply the grouting hose connections, a signal is given and the plug cock on the discharge grout line is opened. The grout is then injected with the initial velocity of the air in the supply main, but with a terminal velocity materially less, due to the expansion of the air within the drum. The air connection is then shut off and also the grout line cock is closed to prevent grout or water coming back into the drum. The three-way cock on the air connection is then thrown over to allow air within the drum to escape; after which the cycle of operations is repeated.

A DRIFT BARRIER OF STEEL CABLES STRETCHED BETWEEN CONCRETE PIERS.

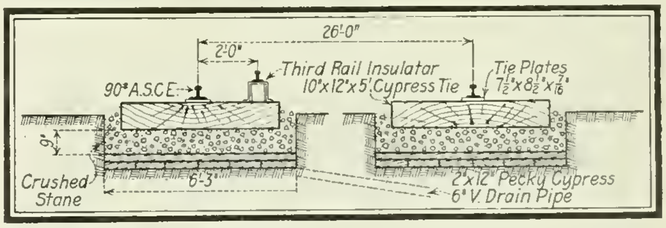
To protect from drift dams the lower channelized reaches of White River in Western Washington, a drift barrier constructed as indicated by the accompanying sketch has been erected. As described by H. H. Wolff, Engineer, in Proceedings American Society of Civil Engineers, Vol. XLII, p. 451, calculations for this barrier were based on solid dam pressure length equal to width of channel and height 8 ft. Stresses were computed by suspension bridge formulas with deflection of cables one in four. On the assumed data, the horizontal pressure to be taken up by the anchorages is 1 ton per lineal foot. This is irrespective of the length of span. Assuming a coefficient of friction of 0.5, the weight of concrete at 2 tons per cubic yard, and a safety factor of 2, it is evident that 3,488 cu. yd. are necessary for anchorages in the 1,744 lin. ft., whether the spans are long or short. The size of the piers is proportionate to the length of the span. In order to make the spans self-supporting, and thereby eliminate intermediate supports, it was decided to make them as short as possible, within the limits of leaving ample waterway and of having sufficient yardage in each pier so that, with the height necessarily fixed by the number of cables, the design of the pier could be such as to keep the center of gravity low. A distance of 64 ft. from center to center of piers was adopted. Ten horizontal cables were used, and two for diagonal trussing. The horizontal cables were given a sag of 1 ft. in the center to allow a deflection of that much (or approximately 1 in 40) for the clear span. They are crucible-steel wire rope, 1 in. in diameter, and have an ultimate strength of 30 tons each. They are fastened with wire-rope clips to eye-bars of 1½-in. mild steel extending through the middle of the pier. The piers are diamond-shaped, and have a center height of 11 ft.; their tops have a slope of 1 in 3 in order to allow drift to ride up on them, and the sides are battered 4 in. to the foot. The idea of this design is that lodged drift will be filled around with sediment and form a permanent dam.



Wire Cable Drift Barrier Dam.

A SOLID TRACK CONSTRUCTION ON UNSTABLE GROUND.

In building tracks for a bridge crane for the Texas City Transportation Co., at Texas City, Tex., difficulty was had in securing solid foundation for the inshore track rails. As designed the crane ran on three rails, one along the outer edge of the wharf and two inshore 92 ft., as shown by the sketch. The ground on which the inshore tracks came was clay filling and called for some construction more stable than cross-ties on the natural soil. The construction shown proved successful. Two trenches, one for each rail, were excavated in the clay and lined on the bottom with a double layer of cypress 2-in. planks. The trenches were then filled with broken stone ballast in which the wood ties were set in the usual manner. To drain the soil in the vicinity of the trenches 6-in. tile pipe were run to an outlet in the bulkhead wall. These drains are indicated in the illustration. The length of the crane tracks was 756 ft. The engineer was Theo. A. Palanskey, chief engineer, Texas City Transportation Co.



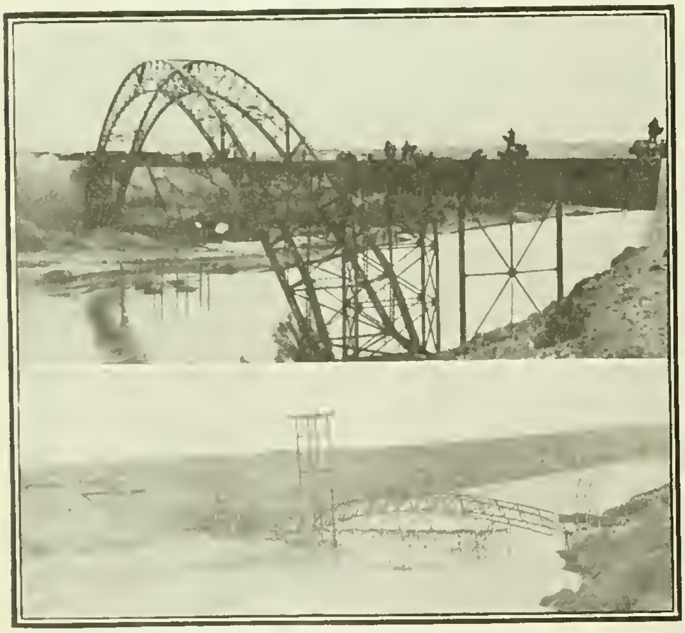
Track Foundation on Filled Ground.

BONDING GRAVEL FOR GRAVEL ROAD CONSTRUCTION.

When gravel is deficient in bonding material there is often added thereto what is called a bonding gravel. This bonding gravel should consist of hard pebbles, sand and clay and should be well graded from fine material to a size that will just pass through about a ¾-in. ring. It should contain at least 40 per cent, by volume, of pebbles that will be retained on a ⅛-in. square mesh and from about 15 to 25 per cent, dry weight, of clay, and preferably not more than about 5 per cent of organic matter. The use of bonding gravel of this quality will make possible the construction of an entirely satisfactory gravel road with the use of a gravel so clean and consisting of such hard pebbles that its use for road purposes without such a binder would be almost out of the question. This composition of bonding gravel is recommended by H. E. Bilger, Road Engineer, Illinois State Highway Department.

THREE HINGED STEEL ARCH BRIDGES ACROSS THE COLORADO RIVER AT NEEDLES, CAL.

The longest three-hinge, steel arch and the third longest steel arch bridge in the United States has been recently completed across the Colorado River near Needles, Cal. The arch has a span of 592 ft. between end hinges, and a rise, center to center of hinges, of 100 ft. The roadway platform extends 8 ft. to end trusses beyond the end hinges and so is 608 ft. long. This platform is carried by suspension from the arch but acts as a horizontal truss carrying its own wind thrust to the towers. The arch trusses are spaced 25 ft. between centers. but the width of the plate girder approach spans is 22 ft. The roadway throughout has a clear width of 18 ft. Pin hinges were used at the arch ends but the crown hinges are of the ball and socket type. The method of erection as indicated by the second illustration, was to set up the half arches complete and with their crown ends supported on a temporary tower at mid-span, and then by means of the tower to hoist and connect the crown ends. The erection tower was built on pile bents of material used later in the floor system and was enough narrower than the width of arch to allow the trusses in rising to straddle it. The designer was J. A. Sourwine of Sourwine & Mahoney, Consulting Engineers, San Bernardino, Cal., and the builders were the Kansas City Structural Steel Co., Kansas City, Mo. Thos. McCurnin was superintendent of construction and J. P. Kemmerer was construction engineer. The bridge cost $75,500, which, for a total length of 832 ft., was about $907 per linear foot and about $5 per square foot of roadway.



Longest Three-Hinged Steel Arch Bridge.

OVERHEAD EXPENSES PENNSYLVANIA HIGHWAY DEPARTMENT.

A statement of the several overhead expenses of the Pennsylvania State Highway Department for the year, Jan. 1, 1915, to Jan. 1, 1916, based on the total amount of productive expenditures, is as follows:

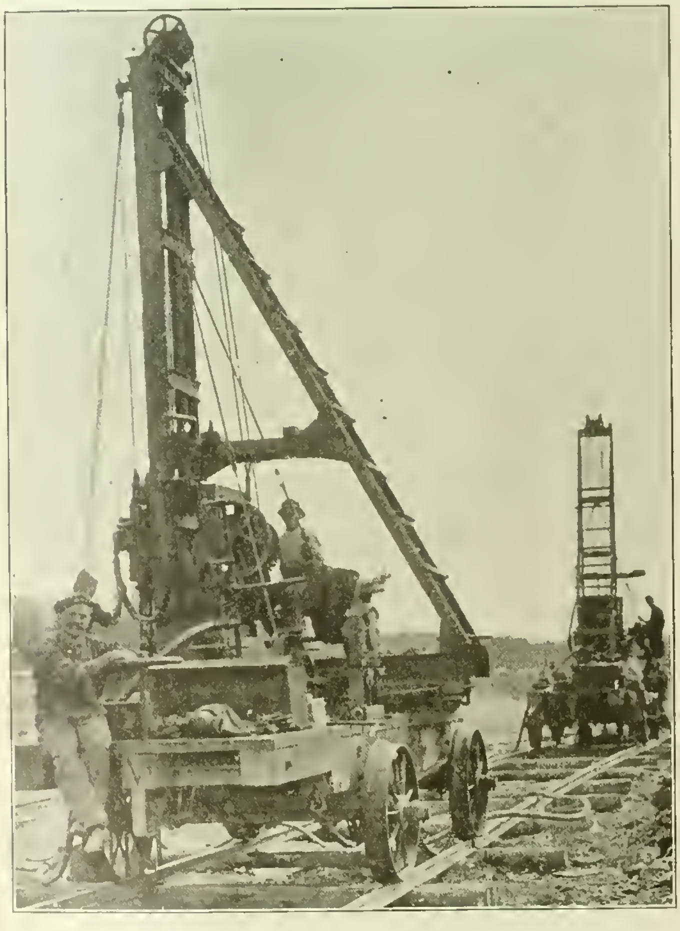
Nature.	Percentage cost.
Department salaries (see note)	.030%
Operating expenses:	
Department and 15 division offices	.017%
Traveling expense:	
Commissioners, engineers and superintendents	.010%
Total percentage cost of overhead expenses	.057%

Note: This figure is in excess of the actual percentage cost of salaries properly chargeable to construction, maintenance and engineering, as a certain portion of same applies to the Bureau of Township Highways and the Bureau for Registration of Automobiles, which Bureaus, although requiring considerable attention, have no productive expenditures.

In addition to which was incurred contingent expenses, such as postage, telephone, rental and toll charges, telegraph service, janitor service, office equipment, etc., amounting to a percentage cost on productive expenditures of .0097 per cent.

DEEP HOLE WAGON DRILLING RIGS FOR HEAVY EXCAVATION.

Since their early use in the Detroit River channel improvements, wagon drilling rigs have become popular where large areas of rock have had to be drilled for steam shovel excavation. The illustration shows two of these machines used on the Champlain Canal and depicts clearly enough their general features. By means of the turntable mounting, the machine, within location of the track, drills three lines of holes, one midway between rails and one each side of the track; the outside rows are 10 ft. apart. The mobility of this machine gives it a high hole production. On the Champlain Canal drilling 12-ft. 4-in. holes spaced 5 and 10 ft., the footings per shift per machine ranged between 160 ft. and 200 ft. On lock chamber excavation at St. Mary's Falls four machines drilling holes bottoming 4¼ in. and 4½ in. and from 18 ft. to 27 ft. deep, averaged from 58 ft. to 80 ft. per shift. On the Sag Channel of the Chicago Drainage Canal 11¾-ft. 3½-in. holes were drilled at the rate of 199.1 ft. of hole per 10-hour day for 2½ years. These data are furnished by the Ingersoll-Rand Co., New York City.



Wagon Drilling Rigs on Champlain Canal.

WELL WATER FOR CONCRETE HIGHWAY CONSTRUCTION, SAN JOAQUIN VALLEY, CALIFORNIA.

Contributed by J. B. Woodson, Fresno, Calif., Division Engineer, California Highway Commission.

A continuous and ample supply of water is one of the absolute necessities in the construction and curing of a concrete pavement. The building of the California State Highway through the great floor of the San Joaquin Valley presented the Highway Commission a problem as to how and where to obtain water for the construction of the concrete pavement. For a distance of more than two hundred miles there were but few surface sources of water, except during the winter and early spring. If water is piped over any very considerable distance the amount of money tied up in pipe alone is large, and a contractor handling a section of from five to twelve miles of highway does not care to make such an addition to his equipment.

In the San Joaquin Valley the water level along the route of the highway is from 25 to 70 ft. below the surface. Wells were sunk at convenient intervals along the right of way of the highway. These wells were usually cased with the ordinary black butt joint casing 6 in. in diameter. The cost of the wells averaged 87 ct. per lineal foot. A majority of the wells had to be sunk from 15 to 25 ft. below the water level in order to reach a satisfactory material upon which the casing could be landed. Wells of this diameter have always supplied ample water for construction and curing of the pavement on this route of the highway. In a few cases the contractor has pulled the casing upon the abandonment of a well, but this practice has not proved economical, and generally the casing has been left in place on the completion of the highway.

PUTTY FOR PLUGGING SEEP HOLES IN WATERPROOFING CONCRETE SWIMMING POOL.

The holes were drilled through the concrete and were irregular in shape, so that plugging with wood or like material was out of the question. Also, considerable water under pressure was flowing from them. This prohibited plugging with a cement mortar, or any other slow setting material. The writer used the following for this work: 1 part Portland cement; 1 part oxide of lead; wet down with equal parts of glycerine and sodium silicate.

This was moulded by a workman, using his hands, until it reached about the consistency of fairly stiff putty. Sufficient quantity was then forcibly rammed into the hole and held in place with the hands for about a minute, when it became sufficiently set to hold the pressure. These holes were filled to within about an inch of the surface with this putty and then brought to level by slushing in some of the waterproof cement mortar. Where the water is coming through holes of large diameter such as would be occasioned by a pump sump or suction left open until all else is waterproofed, the best method is to divide the hole into several small sections by holding or temporarily securing a wood partition in the hole, first filling one section with the above putty, then, when set, removing partition and filling next, and so on, until entire aperture is sealed. The writer has closed and made absolutely watertight and irregular a hole several inches in diameter through which water was spouting. In this instance a 5-in. greased iron pipe was inserted in the center of the hole of sufficient length to reach through the thickness of the concrete floor. The space between the outside periphery of the pipe and the inside edges of the hole was then rammed nearly full of the aforementioned "putty" and held until set, when pipe was removed. This reduced the size of opening from 7 to 5 in. A 2-in. pipe was then inserted and the above mentioned procedure repeated. This left a 2-in. hole, which was small enough to plug at one operation. Waterproof cement mortar was then flushed over the whole up to the level of surrounding floor. Data given by C. S. Nichols, civil engineer, in "Structural Conservation," April-May, 1916.

PORTABLE SHACKS FOR SMALL CONTRACT WORK.

Contributed by J. C. Worrell, Excelsior, Minn.

When we started some small bridge work in Montana in 1913, we put up canvas tents for sleeping and dining room purposes. About two hours after we had set up the tents for the first job, a dust and rainstorm blew up just as we were eating dinner. The dining tent was blown down and before we could get it up again, the food was full of sand and everyone was drenched with rain. Almost immediately we began making plans to put up portable lumber shacks. The lumber arrived in a few days and the shacks were ready when we moved to the next job.

These shacks were made of 1x10-in. boards used as siding and 2x4s for plates. There was a 2x4 plate at the eaves, one at floor and one between, and the siding was nailed to the edge of the 2x4s. The sections were made about 8 ft. wide so as to be easily handled and loaded on a flat car, and the plates extended about 1 ft. beyond the edge of the siding so as to provide for a splice. They were fastened at each splice with two $\frac{5}{8}$-in. bolts.

The distance to the eaves on the lower side of the roof was about 6 ft. and on the higher side about 8 ft., depending on the width of the shack. The roof was made of 1x10-in. boards running parallel with the slope and three lines of 2x4s were placed edgewise at right angles to the boards. The roof was bolted similar to the sides and was also fastened down to the sides with hooks and staples. Posts were placed 8 ft. apart under the center line of 2x4s so as to prevent sagging in the roof. One thickness of heavy tar paper to cover the shack kept out the wind and rain and made much more comfortable quarters than a canvas tent.

The first cost of this shack is about double that of a good canvas tent, but it will give much better and longer service than the tent, and can be taken down at the end of the season and used for other purposes. It is as easily set up and taken down as a tent, and can be stored for the next season, or sold to a farmer for more than the original cost of the lumber.

COST OF STATE LABORATORY TESTS OF ROAD CONSTRUCTION MATERIALS.

At the laboratories of the New York State Highway Commission, according to statement made by Commissioner H. E. Bond, there was tested in 1915, 800,317 bbl. of cement. This was a larger amount than was tested in any previous year. The cement was supplied by 23 different plants, and inspectors were maintained at the following plants: six in New York, three in New Jersey, thirteen in Pennsylvania, one in Maryland. In 1914, $11\frac{1}{2}$ per cent of the cement tested failed, while in 1915 only 8.63 per cent failed. The physical laboratory also tested 1,444 concrete cubes, 973 samples of sand and gravel, 947 samples stone. The chemical laboratory tested 2,017 samples of oils, asphalts, asphalt blocks, paints, etc. This is an increase of $15\frac{1}{2}$ per cent over the largest amount handled in any previous year. These tests for bituminous material represented 16,000,000 gal. of material, and besides this there were tests made representing 777,797 asphalt blocks. There were 269 lots of paving bricks submitted for test, representing 22 different brands or approximately 27,000,000 bricks. From this large amount, 13.6 per cent was rejected by the laboratory test. This does not include the amount rejected and culled in the field. The following cost for doing this testing includes the laboratory work, field sampling and inspection, and our office, or bureau charge:

	Tests.	Cost per test.
Oils, asphalts, asphalt blocks, paints, etc.	1,748	$ 6.83
Cement	867	11.47
Brick	269	7.70
Concrete cubes	1,444	79
Sand and gravel	973	4.06
Stone	947	2.79

METHODS AND COST OF CONSTRUCTING A SMALL BRIDGE PIER IN THE POTOMAC RIVER.

Contributed by Elliott Vandevanter, Contracting Engineer, Baltimore, Md.

The work described in this article is very small and is not unusual either in design or in the methods used in construction. The writer realizes that a description will prove uninteresting reading to the experienced engineer or contractor. But because of the smallness of the work opportunity is given to describe it in detail and this may help some of the beginners in the profession. The majority of articles describe works of such magnitude that it is necessary to pass over the details hurriedly and the beginner can find little of immediate use to him.

The work was begun in October, 1910, and was finished about the last of December of the same year. It consisted of building a new pier in the center of the Potomac River about ten miles above Cumberland, and of reinforcing the old stone abutments, so that the old truss bridge could be replaced with plate girders of one-half the span.

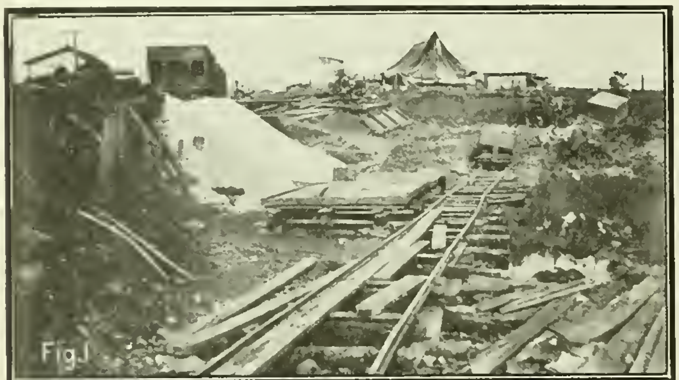


Fig.1

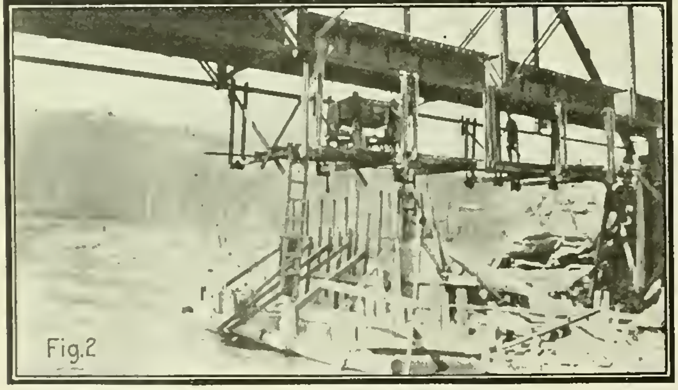
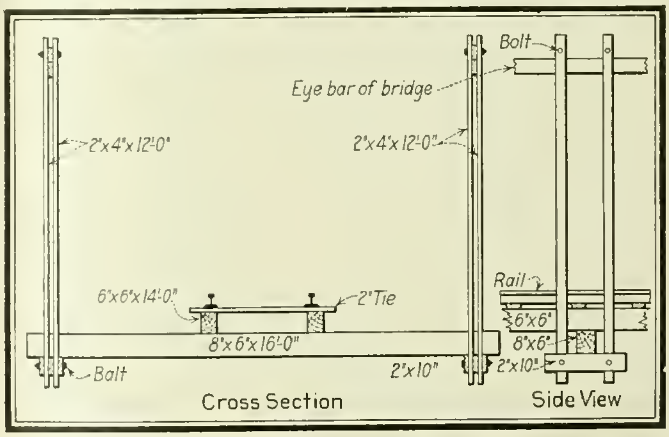


Fig.2

The river at this point is about 80 ft. wide in times of ordinary flow but it rises very rapidly and at flood times covers more than twice this width. At the point selected for the pier the river is about 8 ft. deep normally and the current is very swift as the rocks on the east bank throw the current to the center of the stream. The foundation was 30x14 ft. and a step of about 18 in. was made on all sides before the neat work was started. The batter on three sides of the pier was the same and was about 1½ in. to 1 ft. Of course that on the nose or cut-water was much greater. A heavy coping about 1½ ft. deep, and with 6-in. overhang all around, capped the pier. The pier was 20 ft. high from top of foundation to top of coping.

As the water was too deep to wade in and the current was swift, a raft was built so that the character of the foundation bottom might be investigated. Sycamore, being the only wood available, was used to make the raft. A 1-in. Manila rope was stretched from a tree on one bank to a deadman on the other, about 150 ft. above the bridge. A single block was fastened by a clevis on the rope so that it was free to slide as the raft made its way out into the center of the stream. One end of the rope was fastened to the raft after being passed through the block and the coil of rope was left free on the raft, so that it might be played out as the raft drifted down stream. When the site of the pier was reached the free end of the rope was fastened and it was hoped that this would hold the raft in position so that soundings might be taken off of it. But the current was so swift that the raft was pulled down under the water and the men washed off. No more investigations were tried until a V-shaped crib had been built and sunk about 10 ft. above the nose of the foundation. This served as a breakwater and turned the current on either side. By hanging ladders from the bottom chord of the old bridge and running boards across from these to the breakwater it was possible to get soundings and to determine the character of the bottom. It was found that the bottom was solid rock with practically no earth on top. This was to be expected on account of the wash of the current. Because of this solid rock bottom which offered nothing to hold the sheet piles at the lower end, the ordinary method of driving a double row of sheeting and dumping clay between them to form a puddle was deemed inadvisable as, in case of high water it was feared that the dam would be washed down the stream. One row of sheeting with clay dumped on the outside could not be used for the same reason and also because it would not be possible to hold the clay on account of the swift current. It was therefore decided to build a crib and line it with sheet piles on both sides, in the hope that these piles could be made tight enough so that the pumps could take care of all the water that leaked through. So a crib was built 3 ft. wide and with dimensions about 2 ft. larger than these of the foundations so that there would be no trouble in centering the crib. The crib was built out of 6x6-in. timber with cross pieces of the same size about 4 ft. apart. On top of the bottom course of 6x6-in. timbers a 2-in. flooring was laid. This was done in order to hold the stone which was used in sinking the crib. The crib was built on shore and floated to position behind the breakwater. As the soundings showed that the rock was about a foot deeper on the West side the crib was built accordingly. This caused a little trouble in launching it but no serious difficulty was encountered. After being centered approximately the crib was fastened in position by ropes and loaded with stone and sunk. Sheet piles made from 2-in. lumber were driven on the outside of the crib first and then on the inside. These piles were held in position and tapped with an 8-lb. maul. They were then taken out of the water and the end examined. Where they were bruised and had evidently been bearing they were cut away so that the points of them would conform to the surface of the rock as nearly as possible. This process was repeated several times until the whole point of the pile showed contact with the rock. They were then replaced, tapped several times to be sure they were resting firmly on the rock, and nailed to the top course of the crib. After the crib was sheeted all around bags filled with clay were dropped along the outside edge to stop any leaks caused by the irregularities in the rock which the sheet piles missed. An 8-in. centrifugal pump was then started and it succeeded in lowering the water about a foot. After repairing all leaks that could be



SUSPENDED TRESTLE FOR CONCRETING BRIDGE ROAD.

located, as the water still came in faster than the pump would take it out, the conclusion was reached that the crib could not be made tight enough to keep out the water. It was therefore decided to drive a row of sheet piles four feet outside of the crib and fill this space with clay. Some more sycamore logs were cut and used for upper and lower waling pieces. The 2-in. sheet piles were then driven as much as possible and nailed on the upper wale. As it was not possible to get any appreciable penetration of the piles there was very little holding the bottom of them and in some cases where there was current on the outside, the pile was forced in toward the crib at the bottom. Clay was brought in on the concrete track which will be described later, and dumped between the crib and the outside row of piling. Dumping was continued in one spot until the clay reached the top of the water. Then the chute was moved several feet and dumping resumed. As the clay reached the top several men rammed it so that it might be compacted as much as possible, and thereby force the bottom of the sheet piles against the bottom waler. By this time a 4-in. Emerson pump had been added to the 8-in. centrifugal and pumping was resumed. As the water fell and leaks were discovered, they were patched up by stuffing empty bags in the crevices where possible and ramming the clay in the puddle walls over the point where the water appeared to be coming through. If this did not stop the leak bags of clay were dropped outside the outer row for 2 or 3 ft. each side of the leak. Dumping loose clay outside the puddle wall was also tried but was not successful as the current was so swift. Finally the dam was made tight and the water was lowered until the rock was uncovered for about half the width of the cofferdam (the rock on the east side was about a foot higher than that on the west). Men were put in with boots on and long handled shovels and had just completed cleaning off the little clay there was on top of the rock when suddenly the water began to boil up out of the rock nearly in the center of the foundation. The pumps were speeded up but the water rose until it was about 2 ft. over the highest point of the rock. There it was possible to hold it but it could not be lowered an inch. After several days of fruitless pumping, as the inspector had seen the clear rock on half the foundation and one could tell by sounding that the other half was clear, permission was given to concrete. A fissure had opened up in the rock, under the pressure of the head of the water on the outside over that on the inside, and let the water in under the cofferdam. The cofferdam was allowed to fill up and an effort was made to grout this fissure but it was unsuccessful. As the rock on the bottom was rough and solid there was no object in trying to unwater it entirely. Pumping was stopped and the water allowed to rise to its normal height, and concreting was begun.

The railroad approached the bridge from the east on a 15-ft. fill about 100 ft. long. A switch for unloading materials had been put in at the end of the fill. A one-legged trestle was built on the side of the fill and the track from the siding extended out on it, so that cars could be run out there and dumped by gravity. The bents were 7 ft. apart, the caps 10x10-in. and the stringers were usually two pieces of 6x6-in. laid symmetrically with respect to the rail. There was only one 6x6-in. left for the last stringer however, and, as usual, a car of stone was waiting to be unloaded and the stone was needed. So a coal car loaded with 50 tons of stone was run slowly out on the trestle and dumped. The one 6x6-in. stringer sagged several inches as the trucks of the car passed over it but fortunately, held. It was a very anxious moment for those in charge, however, and the benefit derived did not justify the risk taken. The legs and battered braces were cut in the adjoining woods and were at least 8-in. in diameter and not over 7 ft. long. The cement was unloaded on a level with the switch and stored in a tent (see Fig. 1). From here it was dropped through a chute directly onto the mixing board. Two mixing boards were placed together. Five men were kept mixing, four turning and one attending to cement and water. After mixing a batch on one board they changed to the other while four men loaded the mixed batch into a car and hauled it out to the foundation and dumped it. One man was kept busy loading wheelbarrows with stone and sand. As the distance was very short the mixing gang wheeled the material onto the board, dumped it and returned the wheelbarrows to place. This was found to work very satisfactorily, as the mixing gang mixed the concrete a little faster than it could be hauled away. When they had both boards full the mixing gang was put to work getting out cement until the hauling gang had caught up with them.

The question of how to get the concrete to the forms caused a great deal of worry and discussion. The idea of hanging a track from the lower chord of the old bridge was finally adopted because it was cheaper than building a trestle and because it was above ordinary high water and was not liable to be washed away. This is very important in this section as floods are frequent, sudden and severe. The illustration and drawing describe this structure better than words can. There is one point that should be mentioned, however, as it nearly caused a serious accident. Be very sure to leave sufficient room from the bolt hole to the end of the timber so that the bolt may not split out and if there is any doubt reinforce the end of the timber in some manner. It was thought that sufficient room had been left, but the jar of the car's dumping split the end of one of the pieces which was a little brash and let a laborer fall from the trestle. Fortunately he lit in the water between the crib and the outer row of sheet piles and was unhurt save for a jar.

In filling the foundation the concrete was mixed without the addition of any water at all, with the idea that it would take up the necessary water from that in the foundation and there would be less to push out. Were the writer confronted with this condition again he would add enough water to the concrete to form a thick paste so that the sand and cement would be held together better when deposited in the water. It was noticed that in dumping the concrete from the car through the chute some of the fine cement blew away and some more floated to the top of the water, forming a greasy scum. Additional cement was added to overcome this but the writer feels that the loss could have been avoided to a large extent by the addition of a little water. A rough wooden tremie was used until the concrete reached the top of the water. Then the tremie was discarded and the concrete dumped directly onto the pile which had been formed. Two men shoveled this off gradually into the water, thus preventing any wash and further loss of cement. Concreting was begun in an upstream corner and the water gradually driven ahead of the concrete and out of the down-stream corner. After about two-thirds of the foundation had been filled the concrete was allowed to set up for several days. Pumps were then started again and the remainder of the dam was unwatered without any difficulty. It was found that there was a layer about one foot deep of fine cement and silt which had collected on the bottom of the part unwatered. This was held in suspension by the water as long as there was any flow out of the foundation but when this stopped, the water allowed it to settle. It had a greasy appearance and was sticky and slimy but had no cementing properties, as some which seemed to have the most cement in it was saved, but showed no properties of cement even after several months. The slime was cleaned out and concreting resumed. The concrete which had already been deposited was in good condition and entirely satisfactory as far as could be judged from appearances. As soon as the foundation was filled with concrete the forms were set up. As the force was small this required several days. But concreting was resumed before the concrete in the foundation had gotten hard. This work was done in the late fall and the thermometer was seldom above 45 degrees although we had very little freezing weather. It was about two weeks before the concrete in the foundation got hard enough so that a stone lying on the surface could not be kicked out with the foot, or a nail easily driven into it. This slow setting can be easily accounted for by the excess of water in the concrete, the cool weather and the fact that there was about two inches of water over the foundation most of the time. Concrete was dropped into the forms through the chute and was then thoroughly worked over and spaded by two men. About twenty-five yards of concrete per day was the average placed. The only sand available was glass sand and as this was expensive and of uniform size the engineer allowed the use of stone screenings for half the amount of sand required. This was very satisfactory giving a uniform and dense concrete.

COSTS.

Breakwater—	
Building, placing and sinking—Labor	$ 43.19
Material	22.00
Total	$ 65.19
Cofferdam—	
Labor	$516.76
Labor, digging and hauling 55 yd. clay for puddle	20.01
Lumber, 8.34 M. B. M. at $20	166.80
(Only labor charge for lumber cut in woods.)	
Total	$703.57
Trestle for Unloading Materials—	
Labor	$ 45.83
Lumber, .5 M. B. M.	10.00
Total	$ 55.83
Concrete Trestle—	
Labor	$ 75.62
Material, 2 M. B. M. at $20	40.00
Total	$115.62
Excavating Cofferdam—	
Labor	$196.97
Coal, oil, etc.	15.00
Total	$211.97
Two Mixing Boards, 10x14 Ft.—	
Labor	$ 7.71
Material	12.00
Total	$ 19.71

Unloading stone cost 12 ct. per ton.
Unloading sand cost 3 ct. per ton.
Unloading 15,000 bd. ft. lumber cost 65 ct. per 1,000 ft. B. M.
Unloading cement (carried about 50 ft.) cost 2.5 ct. per bbl.
Mixing, hauling and placing concrete cost $1.05 per cu. yd.
Forms, including material, building, erecting and stripping, cost $1.74 per cu. yd.

It might be interesting to describe a little scientific management which was tried in unloading cement. Nine men and a foreman were engaged in unloading a car. The cement was carried about 50 ft. on a level. The men were timed first, as they were working without their being aware of it, for 1,130 seconds. In this time they carried 30 bags or one every 37 seconds. Each man was then made to make two trips between the tent and the car just as fast as he could go, most of them going on a jog. Then they were allowed to rest from 30 to 45 seconds, and the operation repeated. In 1,452 seconds of work and 796 seconds of rest or a total of 2,248 seconds they carried 72 bags or one every 31 seconds, a saving of six seconds per bag. This was an exceptionally quick and intelligent gang of Italian laborers. They took the experiment as a novelty and entered into it with zest. It is doubtful if they would have put the same vim into it had it been continued long. The big difficulty with scientific management on contract work, especially on small jobs, is that as soon as the men are trained to do one kind of work they must be taken off this and put on another kind. It is also very hard to get a foreman with intelligence and interest enough to train the men properly.

Laborers were paid $1.75 for ten hours, foremen $100 per month, carpenters 35 ct. per hour and firemen 25 ct. per hour.

Electric Steam Shovel Dipper Door Trip.—At the Michigan mines of the Penn Iron Mining Co., Vulcan, Mich., a special electro-hydraulic shovel is employed on which an electric dipper door trip is employed. A weight on a long arm suspends from a horizontal shaft and tends to hang vertically, being parallel to the dipper and tends to hang vertically, being parallel to the dipper handle when the dipper is down. A small catch holds the shaft from turning as the dipper is hoisted, and when the dipper handle is horizontal the weight is ready to fall as soon as the catch is tripped. On the same horizontal shaft is a short arm, the end of which is connected by a chain to the latch of the dipper door.

EXPERIMENTAL STUDIES OF STRAWBOARD WASTE PURIFICATION.[*]

By Harry B. Hommon, Chemist, U. S. Public Health Service, Cincinnati, Ohio.

By authority of an act passed by Congress Oct. 14, 1912, the scope of the work of the United States Public Health Service was extended to the investigation of sanitation and sewerage, and the pollution, either directly or indirectly, of navigable streams and lakes of the United States. Immediately following the passage of this law, a comprehensive study of the pollution of the Ohio and Potomoc River watersheds was begun. The early surveys along the Ohio River and its tributaries indicated that among the various industries contributing waste liquors, the strawboard plants, on account of their location in many instances on small streams, discharge the largest quantity of wastes into streams with the lowest dilution. This industry is located principally in Ohio, Indiana and Illinois, these three states producing more than 85 per cent of the total strawboard in the United States, and the state of Indiana 50 per cent of the total product. The surveys also revealed the fact that there were no purification plants among all the industries visited, although there were instances where plants had been abandoned on account of the adverse court decisions affecting the disposal of their wastes in such a way as practically to prohibit the operation of the mill.

The Manufacture of Strawboard.

The process of manufacturing paper from straw has been so well described by Prof. R. L. Sackett, formerly of Erlham College, in his report[*] of studies for the Disposal of Strawboard Wastes that I am quoting the essentials of the process from his report, in order that a proper understanding may be obtained of the raw product, the different steps in the manufacture and the wastes produced.

> **Steaming in Rotaries.**—The straw is first subjected to a cooking process by steam and lime. A large ellipsoidal rotating steel boiler called a "rotary" . . . is filled with straw, which is then cooked down with steam, then again filled and cooked down until the rotary boiler has been completely filled. The process of filling a rotary occupies from six to twelve hours. The final charge consists of about 6 tons of straw and 30 bushels, or 2,100 lb. of lime in the form of milk. The mixture is then rotated and cooked under 40 lb. of steam pressure for 12 hours. . . . This apparently severe chemical and mechanical action results in a rapid softening of the woody fiber and in the reduction of the straw to a dark-yellow, pulpy mass. This "stock," as it is called, is stacked in piles 10 to 15 ft. high to drain.
>
> The yield of pulp at this point will be from 75 to 80 per cent of the weight of the original material.
>
> The material is allowed to stand in these piles for 24 hours or more to drain. After it is thus drained it contains about 50 per cent of water and from 6 to 7 per cent of lime. This is equivalent to from 12 to 14 per cent of lime in the dry straw. Since the original charge of lime and straw was in the proportion of 2,100 lb. of lime to 14,100 lb. of straw and lime, or about 14 per cent lime, practically none of the latter has drained out with the condensed steam. This drainage from the stock piles forms but a small part of the waste sewage. It is straw-colored and very turbid, carrying a small quantity of fiber broken fine in the rotaries.
>
> **Washing.**—This process is much more drastic, and it is here that the great volume of waste is produced.
>
> The stock is run through washing machines for the purpose of removing the lime. . . . The washing machine consists of an oval channel about 3 ft. wide, around which the stock travels, being supplied with copious volumes of water. Across this channel is placed a cylinder 42 in. in diameter and 42 in. long, having longitudinal ribs or flanges about ¾ in. square in section and ¾ in. apart. Meshing with this, like the teeth of geared wheels, is an idler, below, of similar size and form. These wheels, revolving, lift the water and straw to a level several inches higher than that in the oval channel, whence it flows by gravity halfway around its course to a point where it meets a revolving brass screen of fine mesh, through which a part of the water escapes, carrying with it finer particles of fiber and free lime. The remaining straw, with additional volumes of fresh water, now passes many times through the rolls, which further mash and break the fiber, and around to the screen where more straw, lime and water escape.
>
> **Drying.**—After the washing process the straw, with a considerable volume of water, is led to a train of rolls, consisting of three parts—first, the wet end; second, the hot rolls; third, the trimming and cutting machine. As it comes from the washers the material is run into vats, where it is mixed with large quantities of water and passed

---

[*] Paper before joint convention of Indiana Sanitary and Water Supply Association and Indiana Engineering Society.

[*] W. S. and I. Paper No. 113, U. S. G. S., 1905, pp. 13-15.

over hollow cylinders having fine wirecloth faces, which allow the water to escape, leaving the fiber on the surface of the cylinder. This makes a web of paper on the felt. The pulp, which is now about one-third straw and two-thirds water, travels up and down, over and under a double train of hot rolls, heated by steam that is carried in through hollow bearings. As the pulp passes on through the train it is constantly pressed and dried, until finally it is separated from its cloth support and goes to the trimming machine, where it is cut into sheets of proper size. It now contains about 10 per cent of water and a small quantity of lime. The board is manufactured in many thicknesses and weights. Just before it is trimmed it may be coated on one or both sides with a thin paper facing or finish.

Present Method for Disposal of Wastes.

Where strawboard mills are located on large rivers and the water below is not used for domestic purposes, the wastes can be discharged into the river without treatment and no serious nuisance result, but where the volume of the water flowing in the stream is only three or four times that from the strawboard mill a nuisance is likely to occur in the stream, the seriousness of it depending upon the season and the length of time between rainstorms sufficient to move along and distribute sludge deposited over the bed of the river in low water.

The only methods used today at the strawboard mills to relieve the streams of the burden of carrying off practically 45 per cent of the raw product, most of which is in colloidal form and will not settle out, is to dig settling ponds and store the wastes in these ponds for periods varying from a few days to weeks and drain the supernatant into the river. Injunctions have restrained some mills from discharging their liquid wastes into streams and those desiring to continue in operation have been forced to build settling ponds of sufficient storage capacity to allow the water to drain away into the ground water or evaporate. Settling ponds are unsatisfactory as they only remove the settleable suspended solids, leaving the organic matter in solution, the color and the finely divided suspended matter to be discharged into the stream. Ponds large enough to provide storage until the water evaporates or seeps away into the ground water are expensive to build, require constant attention, are unsightly and the large volume stored is always a menace to the river, especially if the level of the water lies above the river and the banks subject to inundation.

The importance of the problem of purifying the waste liquors from the strawboard mills has long been realized, especially by the State Boards of Health of Ohio, Indiana and Illinois, and particularly Indiana, where, as already stated, about 50 per cent of the total output is made. At the request of the Secretary of the Indiana State Board of Health it was agreed that the U. S. Public Health Service and the State Board of Health of Indiana co-operate to work out a purification process for treating strawboard waste that would protect the stream of water receiving the wastes, and at the same time not add so much to the cost of producing a ton of strawboard that unfair competition would result where no treatment plant was required.

Studies Previously Made for Disposal of Waste Liquors from Strawboard Plants.—In 1903 Professor R. L. Sackett* of Erlham College carried out a series of tests, the conclusions of which were as follows:

(1) Strawboard waste is an extremely stable substance which does not degenerate when kept in clean containers, but when mixed with other substances of a putrescible nature, such as sewage and other organic matter in streams, it becomes very foul and objectionable.

(2) Simple sedimentation is not effective in the purification of strawboard waste.

(3) Chemical precipitation appears to be satisfactory from every standpoint except that of cost, which makes it commercially impracticable.

(4) Filtration without previous sedimentation is impracticable, but combined with sedimentation is an aid to the process.

(5) The sulphates of iron and alumina are the most effective chemical precipitants for the purification of strawboard waste, but so large are the amounts which it is necessary to use that the cost is prohibitive.

(6) Lime is of no value as a precipitant.

(7) The combination of carbon dioxide and milk of lime is effective when properly applied, and the process can be economically maintained if conditions are favorable. The results of experiments indicate that 75 per cent of the suspended material can be removed by precipitation with carbon dioxide and milk of lime at high speed of treatment. Higher efficiencies can be obtained at lower speed and by the combination of sand filtration. It is believed, however, that the latter would be necessary only in extreme cases.

In a supplementary note Professor Sackett cites the objections offered by one large company, that the cost of such a process as recommended above would be prohibitive, as the margin of profit was so low as to drive industries forced to adopt the process out of business.

Two years after the investigations of Professor Sackett additional studies* were made by Prof. Earle B. Phelps, formerly of the Institute of Technology, Boston, Mass.

This work was a continuation of the studies made by Sackett along new lines and was undertaken to meet the objections offered against the earlier recommendations for treating strawboard wastes, namely, the high cost of installation and operation. After many observations and tests during the summer of 1905, the following summary of conclusions were given by Professor Phelps:

The present method employed for the treatment of strawboard waste liquor, that of sedimentation in large fields, is unsatisfactory and expensive and proceeds on a wrong principle.

The filtration of the liquor through sand, so-called mechanical filtration, but without coagulants, after a short period of sedimentation will remove 93 per cent of the suspended organic solids and 98 per cent of the total suspended matter determined as turbidity.

Actual experiments have shown that the resulting effluent can be discharged into an equal volume of reasonably pure water without creating a nuisance. In particular, there will be no sedimentation of organic matter. If its discharge into seriously polluted stream should bring about precipitation of sewage matter and consequent nuisance, the blame should in all equity be fixed on those contributing the sewage.

The sludge resulting from the sedimentation tanks, after pressing or spontaneous drying, is innocuous and makes good soil. It has some value as a fertilizer and is particularly valuable to mix with the clay soils of the Middle West to render them more porous. Other uses for this material are suggested, but they require further study.

The cost of the entire process is sufficiently low to admit of its adoption wherever stream pollution is serious.

While the results obtained by Professor Phelps satisfactorily met the objections to the process recommended by the earlier investigations it was considered that the importance of the problem and the discoveries of new methods for purification of sewage warranted further researches covering a longer period of time than was possible when these tests were made and the application of the later sewage purification processes to the treatment of strawboard waste liquors.

After looking over the strawboard mills in the state in conjunction with officials of the Indiana State Board of Health, it was finally decided to build a testing station at the American Strawboard Mill at Noblesville, Ind. There were two reasons for locating the testing station there; first, a permanent injunction had been granted by the courts preventing the mill from discharging its wastes into White River; and, second, it was a large and representative mill.

Design and Operation of Testing Station at Noblesville, Ind.—The original design of the testing station was based on the tests made by Professors Sackett and Phelps and embraced the following equipment:

1. Laboratory in the office of the Strawboard company. 2. Pumping outfit consisting of a 2½-in. centrifugal pump direct connected to a 5-HP. marine type gas engine. 3. Two circular settling tanks, each 8 ft. in diameter and 10 ft. deep. 4. Two chemical solution tanks each 5 ft. in diameter and 6 ft. deep. 5. One chemical mixing tank 6 ft. in diameter and 10 ft. deep. 6. One chemical settling tank 6 ft. in diameter and 10 ft. deep. 7. One mechanical filter 8 ft. in diameter and 6 ft. deep. 8. One tank 8 ft. diameter, 10 ft. deep to be used as a filter, the type of which was to be decided after the wastes had been studied for a few months. 9. Two sludge beds each 12x 12 ft.

The testing station was started in operation Jan. 1, 1915, and has been in continuous operation since that time, except for short intervals when the mill was closed down or when repairs for the gas engine required the testing station to be out of operation.

The laboratory was equipped for making routine suspended matter, oxygen demand, alkalinity determinations, sludge analyses and various miscellaneous tests to control the operation of the tanks and filters.

---

*Loc. cit., pp. 34-35.

*W. S. and I. Paper No. 189, U. S. G. S., 1906, p. 29.

The primary settling tanks, operated as separate units, were provided with weirs to measure the amount of wastes entering the tanks. After passing over the weirs the wastes entered the tanks through 4-in. No. 22 galvanized pipes extending down into the tanks 6 ft. below the outlet and then rose to the surface and were collected in a gutter around the full circumference of the tank. The storage in the primary tanks was two hours. The chemical mixing tank was designed similar to the primary tanks as to measuring the flow, applying the influent and collecting the effluent and the storage period was one hour. This tank received the effluents from the two primary tanks and in addition to the various chemicals for removing the suspended matter and supplying the floc for the mechanical filter. The chemical settling tank, provided with the same equipment for applying and measuring the flow as the other tanks, had a storage of one hour and received the effluent from the chemical mixing tank. The two chemical solution tanks were equipped with rate regulating device for controlling the amount of chemicals added to the wastes and the piping was arranged to deliver the chemicals to either one of the chemical mixing or settling tanks. The mechanical filter was constructed of 5 ft. of sand of the size used in mechanical water filters, the fine sand resting on a screen and the coarse sand on a strainer plate set 6 in. above the bottom of the filter. The wash-water line and the effluent pipe were connected together with a tee at the center of the bottom of the filter and valves properly located permitted washing or operating the filter. The end of the effluent pipe was 6 ft. below the bottom of the filter and was so arranged to operate the filter under the negative head principle. The wash water main provided water at the rate of 1 to 2 ft. vertical rise per minute.

The reason for designing two primary tanks, a chemical mixing tank and a chemical settling tank, was to permit the study of the heavier solids in tanks without the addition of chemicals, and chemical precipitation for removing the finely divided suspended matter in the chemical mixing tank, and coagulation by the use of alum in the chemical settling tank. This arrangement of tanks gave a wide range of operation and as the tests progressed proved very satisfactory in working out the various combinations.

As already stated the entire settling period for all the tanks was four hours when the plant was first started in operation, two hours before the chemicals were added and two hours after. Alum was added at rates varying from 5 to 30 grains per gallon to the chemical mixing tank, but it was soon discovered that the floc formed settled out in this tank with but little effect upon the removal of the finely divided suspended matter, and the filter could not be operated at any practical rate. The chemical feed pipe was changed to apply alum to the chemical settling tank and amounts added from 5 to 30 grains per gallon. The results obtained were slightly better, but in amounts up to 20 grains per gallon there was no visible floc and the filter required 25 per cent or more wash water to keep it in operation. By adding 30 grains per gallon the amount of wash water could be reduced to 10 per cent, but as the total amount of wastes was about 1,000,000 gal. per 24 hours, this amount of chemical was entirely too expensive to be recommended for treating all the wastes. Following these tests various other schemes were tried to obtain a floc by the use of alum that would reduce the amount of chemicals to a practical basis and at the same time reduce the volume of wash water. A heavy dose was added to the influent to the filter and all the floc carried to the sand at the beginning of a run and then the rate cut down, but this did not work satisfactorily; following this test all the alum for a given volume of wastes was added to a small part and after the floc was formed this was added to the main bulk, but the heavy precipitate dissolved and the end results were the same, the filter clogged so quickly that the amount of wash water required was often in excess of 25 per cent.

Realizing that alum alone could not be used to prepare the influent for the mechanical filter at economical rates of filtration it was thought that ferrous sulphate could be used for removing the finely divided suspended matter, especially as the reaction of the raw waste (550 p.p.m. bicarbonate and 200 p.p.m. carbonate alkalinity) was favorable for iron treatment. One of the chemical solution tanks was accordingly filled with ferrous sulphate solution and this solution added to the chemical mixing tank and alum to the chemical settling tank. By this method it was hoped to form a heavy floc with the iron that would remove the fine suspended matter and leave enough alkalinity for the reaction with the alum. The results did not materialize as anticipated and the explanation seems to be due to the fact that both the alum and iron were absorbed by the organic matter of the wastes as mordants. The experience with the chemical precipitation and mechanical filtration was somewhat at variance with the results obtained by Professors Sackett and Phelps, and for that reason the tests were continued over a longer period of time and in more detail than would otherwise have been the case.

Remodeling of Testing Station.—Before all the possibilities of chemical precipitation and mechanical filtration had been exhausted a small cinder filter 15 in. square and 5 ft. deep was constructed and filled with screened cinders. The settled effluent from the primary settling tank was applied on this filter at the rate of 600,000 gal. per acre per day and the effluent after four weeks' operation was so satisfactory that it was decided to remodel the testing station.

The following changes were made:

1. The two primary settling tanks were converted into Imhoff tanks. 2. The chemical mixing tank was turned into a filter made of stone screenings ¼ in. average diameter and 5 ft. deep. 3. The chemical settling tank was changed into a filter filled 6 ft. with 1 to 2-in. limestone. 4. The sand from the mechanical filter was replaced with 5 ft. of unscreened cinders. 5. The extra tank that had not been used up to this time was filled to a depth of 6 ft. with cinders screened over a ¼-in. mesh screen. 6. A roughing filter was constructed and set above the cinders described under No. 5. 7. The small cinder filter that had been in operation up to the time the plant was remodeled was continued in operation.

The material selected for the filters was what could be obtained in most any locality, cinders in particular being available as a rule at most strawboard plants. All the filters have been dosed at the same rate, 600,000 gal. per acre per day, to determine the comparative effiicency of different sizes and quality of filter mediums.

In the discussion of the operation of the testing station during the early part of the tests no mention was made of the sampling or analyses. Samples were taken and analyses made, but the operation difficulties were such that the chemical results did not seem important. With the change from mechanical to biological filters the following schedule was inaugurated:

(1) Readings on the weir in the flume carrying all the wastes was taken every hour. (2) Readings on all the weirs measuring the flow in the tanks and filters were made every hour. (3) Small samples of raw wastes from all devices were taken every 30 minutes for two days and mixed together to form composite samples for suspended matter and alkalinity. Two sets of samples were taken each week. (4) Samples for oxygen demand were taken four days each week, and analyzed and incubated the same day as taken. (6) The volume of sludge in the Imhoff tanks was measured the last day of each month and samples taken for analysis. (8) The station was operated 8 hours per day up to Feb. 1, and 16 hours after that date.

The results obtained from the operation of the biological filters, especially those constructed of cinders, were satis-

TABLE I.—ANALYSES OF THE RAW WASTES, THE EFFLUENT OF THE SETTLING TANKS AND THE FILTERS.

Source.	Time filter has been in operation.	Dilution.	Oxygen demand 24 hr.	Relative stability.	Suspended matter.	Per cent removed total.	Carbonate.	Bicarbonate.	Remarks.
Raw wastes*	....	1:25	34	95	2,416	..	400	400	Straw paper only being made
Settled wastes	....	1:25	109	95	956	61	120	580	Settling period 3 hours
Effluent filter 1†	3 mo.	1:10	79	95	216	91	50	400	Crushed stone screenings
Effluent filter 2†	3 mo.	1:10	74	95	288	88	400	140	Crushed stone 1 in. to 2 in.
Effluent filter 3†	3 mo.	1:3	31	60	68	97	32	274	Unscreened cinders.
Effluent filter 4†	3 mo.	1:3	31	75	88	97	32	226	Screened cinders
Small cinder filter	5 mo.	1:2	21	95	56	98	32	304	Screened cinders

*Flow per 24 hours averages about 1,000,000 gal.

†Rates on all filters 600,000 gal. per 24 hours.

factory, as will be seen from an inspection of Table I herewith. On Feb. 1 the operation of the plant was changed to 16 hours, as already stated above, and it is believed this method of operation will increase the efficiency of the filters and encourage nitrification, and that a full 24 hours' operation of the testing station to correspond with the operation of the strawboard mill would give still better results. Table II gives data on the accumulation and analyses from the Imhoff Tanks.

TABLE II.—THE ACCUMULATION AND ANALYSES OF SLUDGE FROM THE IMHOFF TANKS.

Source.	Sludge produced per million gal of wastes.	Sp. gr.	Per cent moisture.	Per cent nitrogen, dry basis.	Per cent $CaCO_3$, dry basis.	Per cent P_2O_5, dry basis.
Settling tanks	30 cu. yd.	1.02	90	0.39	12	0.20

Sludge freshly deposited in the tanks has a light brown color similar to straw, but undergoes decomposition in the tanks, giving off marsh gas and acts in every way similar to sewage sludge in Imhoff Tanks. It is black, full of gas bubbles when drawn off and has no disagreeable odors when fresh and when dried smells like humus. It dries readily on beds of sand or cinders if not applied in depths greater than 18 in. It has some fertilizer qualities, the tests carried out last spring on corn land showing an increase in yield of about 12 per cent. The season last year for corn was very favorable the unfertilized section of the field in which the tests were made gave a yield of 60 bushels per acre, whereas the best result would be expected on land run down to a yield of 35 bushels per acre. The fertilizer tests are to be continued again this spring on a large scale with different crops on the American Strawboard Farm at Noblesville, and the farm of O. C. Barber, president of the American Strawboard Co. at Berberton, Ohio.

Conclusions.

The testing station will be continued in operation till the first of July of this year to determine the effect of warm weather and the extent of nitrification that will develop in the filters. One filter has been in operation five months and has shown no tendency to clog either on the surface or in the body of the filter, and the effluent is practically free of suspended matter and has but little color, and is stable most of the time, with no dilution. All the filters were constructed above ground and extreme cold weather has seriously interfered with their operation, but as the purification is most necessary in the warm months and the freezing would be minimized in a large plant by building the filters in the ground, it is believed the operation of the plant up to July 1 will demonstrate the kind of plant best suited to purify waste liquors from strawboard plants.

In addition to the devices now in operation, laboratory tests are now under way to determine whether the activated sludge process of treating sewage is applicable to the purification of strawboard wastes.

While the tests have been carried on at the American Strawboard Mill we have had the hearty co-operation of the Indiana State Board of Health and the officials of the company, and we have assurance that if the plant as now designed proves satisfactory the company will install a small permanent unit, the U. S. Public Health Service to maintain general control over the operation to the extent of analyzing samples of the filter effluents and writing reports for general distribution among the various strawboard mills of the country.

HEAT TREATMENT OF CHAINS AS PRACTICED IN ENGLAND.

The annealing process of treating chains, which have been subjected to heavy usuage for some time, has been used in this country to a considerable extent, although authorities differ as to the effectiveness of such treatment. The following data by G. S. Taylor, inspector of factories in England, are instructive as indicating practice in that country:

The close-annealing process is considered the best, and is employed by such firms as have the necessary plant. The chain or article to be annealed is placed in a gas or oil-fired muffle furnace, heated to redness out of contact with the air, and then allowed to cool slowly either in the furnace or covered with dry sand or ashes after removal. Close-annealing prevents oxidation and subsequent scaling of the surface of the metal, and the chain is heated more uniformly than other types of furnaces. Coal or coke may also be used for a close-annealing furnace and a fire-clay gas retort is said to make a good muffle for these furnaces.

Where close-annealing is not employed the chains are annealed in an ordinary reverberatory furnace, as used for heating plates, or in a small furnace of the same kind specially built for the purpose. The chain should not come into contact with the fuel, which should be as free as possible from sulphur or phosphorus. Where an ordinary plate furnace is used the chains are often placed in the hot furnace on Saturday and removed on the following Monday when quite cold. In special annealing furnaces the chains are maintained at a uniform red heat for some time; after removal they are either allowed to cool in a mass on the shop floor or covered with sand or ashes and cooled slowly. It is contended by some that cooling in sand or ashes is unnecessary for wrought-iron articles containing little or any carbon while these precautions are considered essential by others. Possibly the cooling en masse is almost as effective for practical purposes, especially if the articles are covered with plates to prevent the chilling effect of cold air. Several chain users, however, have demonstrated by experiment the advantage of slow-cooling.

A method of annealing, chiefly followed in one district, consists in passing a chain link by link through an ordinary smith's fire. Each link is heated to redness, then removed from the fire and examined carefully while red hot. Cracks or flaws can then be more readily detected. The chain is allowed to cool in the open air. Although for examination purposes this open-fire method of annealing is advantageous it is not to be recommended. In some works the chains are merely placed in a pile on a smith's fire, covered over with fuel and heated up with the air blast. This method is faulty, in so far as some links are overheated, while others are not raised to a temperature sufficient to have any useful effect, and therefore the chains cannot be considered as "effectually softened," although this is difficult of proof.

Another method of annealing is used frequently where wood is readily obtainable. The chains are either placed on a grid, supported above the ground, or hung from a bar supported by the sides of a specially constructed pit or by uprights. A wood pile is built over the chains, oakwood being preferred, the chains are heated by the wood fire and allowed to remain in position until the ashes are cold. Satisfactory results are claimed for this method of annealing, as wood is free from sulphur and phosphorus and does not affect the metal injuriously, while the temperature of a wood fire is comparatively low and the metal is not over-heated and rendered brittle.

CONSTRUCTION OF AN UNUSUAL RELIEF MAP.

Contributed by Burt C. Heinly, Los Angeles, Cal.

A "home-made" relief map has been recently completed by the Bureau of Water Works of the city of Los Angeles which is not only unusual in the exact degree of accuracy obtained, the wide variance of elevation, the national landmarks and the area shown, but also in the methods and the materials employed. The map which created much interest at the session of the Inter-Nation Engineering Congress held in San Francisco last August, was built for the purpose of showing the drainage area of the Los Angeles Aqueduct and its course from the Sierras to the Pacific Ocean, including the city of Los Angeles and the Aqueduct irrigation system now under construction. An area of 10,000 square miles is shown in outline, including the main range of the Sierra Nevadas from Yosemite Park southward, the Sierra Madras and the Mojave Desert to a point within 50 miles of Death Valley. The elevations range from sea level to 14,502 ft., represented by Mt. Whitney, the highest peak in the United States (exclusive of Alaska).

The horizontal scale of the map is 1 in. to the mile and the vertical 1/16 in. to 100 ft. In relief map work the proportions of 1 to 1 and about 1 to 5 are about the limits which can be used. In this case 1 to 5 threw the high and precipitous mountains out of proportion and a 1 to 1 was too small a divergence to show properly the territory in the vicinity of sea level. The 1 to 3 vertical scale was therefore fixed upon as the most suitable. The map is 27 ft. in length with a breadth of 33 ins. The dimensions made it necessary to build the map in 7 sections ranging from 3 to 5 ft. in length, the bases being 2 in. planking, bolted to secure rigidity and finely surfaced. These when joined together form the completed map.

The regulation sheets of the U. S. G. S. furnished the data. In some of this the work had never been undertaken and it was necessary for the city of Los Angeles to enter into a contract with the Government and defray part of the expense of a survey of about 500 square miles. Every 100 ft. contour and in many cases every 50-ft. contour was pantographed directly onto the many fibrous sheets of which the map is built up. On these sheets, also, wherever possible, the 10-in. latitude and longitude lines were drawn on the base tables which had been laid out as a whole by a paper template plotted for latitude and longitude according to the geographical projection tables of the Smithsonian Institute. Knowing the latitude and longitude of the four corners of each section of the table and of each pantographed fibrous sheet, it was possible to place the latter in their exact positions.

It was realized that the choice of material was a most important one. Experiments were made with Bristol board and trunk fibre. On these the edges burred and roughened. Various woods and veneers which were tested showed a disposal to chip and all were subject to warping from variations of temperature. The material that was finally selected is one that is probably new in map-relief making—red vulcanized fibre commonly employed for friction hoists and in the making of gaskets, packings, etc., etc. This material comes in sheets 50x69 ins., is of uniform thickness, is practically impervious to heat, cold or moisture and may be obtained in almost any thickness desired. It was purchased from machinery supply houses in quantity at 18 ct. per pound. A sheet 50x69 in. weighs 10 lb., so that the cost per square foot amounted to 7½ ct. The sheets used on the Los Angeles map were of 1/16 in. thickness, this fitting in exactly with the scale of 1/16 in. to 100 ft.; 1/32-in. sheets were used on 50-ft. contours where the slopes were gentle and could be thus

Relief Map, Los Angeles Aqueduct.

shown to better advantage. About 1,000 lbs. of the fibre was used, of which 25 per cent was waste due to cutting. Where no contours were shown and only bulk was needed, quarter-inch bass wood was used to build up to the elevation required.

The contour lines were transferred by pantographs from the U. S. G. S. topographic sheets to the fibre sheets, which were then sawed out in exact conformity with these lines. After being carefully orientated on the map, each successive layer was fastened in place by brads. For sawing, a scroll jig saw driven by a small motor and equipped with Jennings-Coping No. 3 saw blades, was employed. The fibre sheets were secured in place by ⅝-in. finishing brads, each sheet being very securely nailed to prevent any possible warping or buckling. Where the area of the contour was too small to be cut out by the saw; i. e., approximately 3,000 mountain peaks represented on the map, the method employed was to drive a 1½-in. finishing brad carefully to the proper elevation and then model the peak in a material which the picture molding trade was called upon to furnish. This material is called "compo," a cheap material used as the base for the better grade of gilt mouldings. It is easily applied in plastic or almost liquid form, depending upon the degree of heat to which it is subjected, and when cooled it is of the most durable quality. To handle this, a zinc-lined box was made and connected up with the steam radiator. When summer approached and the steam plant went out of business, an oil burner was used. When all the peaks had been thus formed, either with fingers or palette knife and checked up with dividers, the whole map was bolted together and painted with the hot compo in liquid form until all the sharp lines were obliterated. The map was then turned over to an artist, who, after making a trip along the aqueduct, painted the map in its natural colors as taken from his field sketches. The course of the aqueduct, reservoirs, dams, power houses, tunnels, conduits and siphons are all shown by colors according to construction classification. Tunnels are shown in black, steel siphons in brown and conduits in red. The portrayal of the country with snow-capped mountains, barren desert and irrigated fields is as it appeared during the first week of June, 1915.

The map brings out in striking detail the general geological formation of the country and particularly several important evidences of strong crustal movements which in no other way could be made so evident. These are the San Andreas, the Tehachapi and the Owens Valley fault lines.

Exclusive of the artist, the plan and the work was carried out by the Water Department engineering force under the direction of the Chief Engineer, William Mulholland. The entire time of four and sometimes six men was required for five months in the task. One man at the scroll saw could keep three men busy with the pantographs and two men at work nailing the contour fibre sheets into place.

The writer knows of no method by which such a map could be constructed with a greater degree of accuracy, the methods are extremely simple and the materials are of great durability and comparative cheapness.

Testing Kansas Sands.—Tests of sand from all parts of Kansas have been made by the Kansas Engineering Experiment Station and will be, it is expected, of great value to all users of mortar and concrete in building operations. These are the first of their kind made by any institution in Kansas. Results of the tests in detail are given in a bulletin by R. A. Seaton, professor of applied mechanics and machine design, and I. I. Taylor, instructor in applied mechanics in the college. The bulletin is illustrated with numerous charts and halftones. More than 50 representative samples were tested, having been obtained from city engineers and other officials in various parts of the state. The tests covered sieve analysis, percentage of silt, weight per cubic foot, specific gravity, percentage of voids, and tensile tests of mortar.

COMPARATIVE VALUES OF VARIOUS APPROVED FORMS OF STREET PAVEMENTS AND ROADS.

Contributed by E. M. Re Qua, Madison, Wis.

The life of a pavement is determined by two wholly different factors or a combination of the two—natural durability of the materials of which the pavement is constructed, and the amount of punishment the pavement receives due to wear, tear and age. The destruction due to age is independent of that due to travel. The statement that a certain pavement has lasted a certain number of years means practically nothing as regards its durability unless the quantity of travel, preferably in tons, per square yard, per year is given. The endurance of a pavement is not measured by years but by the total service it is capable of giving. To the neglect of this principle is due the conflicting statements about the durability of various kinds. From the point of economy alone, the following factors must be taken into account in comparisons:

(1) First cost.
(2) Interest on first cost.
(3) Payments to sinking fund to redeem debt incurred for construction.
(4) Maintenance cost including cleaning and watering.
(5) Useful life of the pavement.
(6) Value of the worn-out pavement for purposes of renewal.

Maintenance consists of the following separate divisions besides the cost of watering:

(a) Interest on first cost.
(b) Annual payment to a fund to redeem bonds in (x) years at (x) per cent interest.
(c) Annual payment to a sinking fund to provide sum necessary for reconstruction at the end of (x) years.
(d) Cost of ordinary repairs during life of pavement per square yard per year.
(e) Cost of cleaning per square yard per year.
(f) Total cost per square yard per year.

This latter comparison is for an annual check and is entirely separate from the one above. Compared on this maintenance basis in the city of Boston:

	Life.
Granite blocks, cost annually, $0.58 per sq. yd..................	13 yrs.
Sheet asphalt, cost annually, $0.57 per sq. yd..................	9 yrs.
Macadam, cost annually, $0.78 per sq. yd........................	5 yrs.

It was found there that pavements are often continued in use long after it would be more economical to renew than to repair.

Although cost is the great item in pavement comparison the public in general demands that many more things be taken into account and the following pavements will be compared on the basis of the essentials of a perfect pavement, namely:

(1) Cheapness. No matter how good a pavement is unless the money for its purchase is at hand, it is not available. So the question is, what is the best obtainable with the money you have.

(2) Durability. Some materials have only a certain life whether they are subjected to traffic or not, such as asphalt and untreated wood. Where traffic is the governing factor, it, in turn, is influenced by width of street, character of pavement, presence or absence of street cars and state of repair.

(3) Ease of Cleaning. An economic and sanitary factor.

(4) Resistance to Traffic. Pavements are constructed for the transportation of vehicles and anything hindering this is important.

(5) Non-Slipperiness. The efficiency of a horse depends on his foothold. Infinite strength is of no avail if there is no place to apply it.

(6) Maintenance. Closely allied to first cost and depending on material and traffic. With some pavements, as treated wood and asphalt, a certain amount of traffic is more beneficial than otherwise.

(7) Favorableness to Travel. Ease and comfort of riding and decrease of wear on vehicles.

(8) Acceptability. Lack of noise, reflection of light, radiation of heat, emission of unpleasant odors and other qualities concerning the pedestrian and adjoining residents.

(9) Sanitary Quality. An essential to health in any city.

Sheet Asphalt.—This type of pavement is suitable for use, with a proper foundation, for medium to heavy traffic and in some parts of Canada is used and proposed, with a 6-in. concrete base, for very heavy traffic. It is not suitable on grades steeper than 5 per cent as a general rule but has been used on 7 per cent grades. It wears fairly even, with a tendency towards ruts and holes under heavy traffic. Its advantages are ease of traction, smoothness, comparative noiselessness under traffic, impervious to water, easily cleaned, pleasing to the eye, suitable to practically all classes of traffic, no vibration or concussion given to passing vehicles and comparative low first cost and maintenance. Its disadvantages are, slipperiness under certain atmospheric conditions, disintegrates if excessively sprinkled or otherwise subjected to constant moisture although asphaltum is impervious to either fresh or salt water, becomes soft and wavy under traffic in extreme heat, may crack and become friable under extreme cold, and is not adapted to steep grades.

In 1911, 2,348 mi. of asphalt sheet were laid in Brooklyn, Boston, Buffalo, Chicago, New York, Philadelphia, St. Louis and Washington, D. C. Chicago, Washington, Philadelphia. New York and Winnipeg, Canada, have more than of any other type. Maintenance costs vary from $.35 per sq. yd. in Brooklyn to $.30 per sq. yd. in London, depending on age and traffic. When properly constructed asphalt is good for a life of from 16 to 22 years.

Aphaltic Concrete.—Suitable in most places where sheet asphalt is used and in some where it is not. Has been used satisfactorily on grades of from 2 per cent to 7 per cent with transverse, staggered grooves cut for a foothold on the latter grade. Is slippery in wet weather, with tendency to wear into holes under heavy traffic. Slightly noisier than sheet asphalt, with a life depending mainly on the toughness of the stone aggregate. Cost values are from $1 to $2.50 per square yard, the latter including grading and foundation.

Asphaltic Macadam.—Generally proposed where traffic is not quite heavy enough to necessitate sheet asphalt, with the same foundation as the latter. It may take the place of sheet asphalt on grades greater than 5 per cent. In Canada it is often laid on a Telford base, consisting of stones 8 in. thick laid on edge.

Costs vary from $.77 in Baltimore to $1.36 in Ontario, Canada.

Advantages are freedom from dust, low external and internal wear on road metal, imperviousness and a degree of density of surface, noiselessness, low traction resistance and is sanitary. Disadvantages are slipperiness at times and variability of penetration and distribution of road metal.

Asphalt Block.—This type affords a better foothold than sheet asphalt owing to a coarser stone in the aggregate and on account of the joints between the blocks. An objection is that the blocks have to be all manufactured at one location and transported to the locality where used, while a portable sheet asphalt plant permits a smaller haul. This is counteracted in repair, however, where the removable blocks allow an easy reconstruction without necessity of a resurfacer or mixing plant.

Suitable for residence streets of light traffic minus car tracks, with a probable life of ten years. Cost of construction averages $2.70 with maintenance from $.062 to $.10 per square yard. The pavement is very hard to keep clean when roughened and worn at edges.

Wood Block—Treated.—An ideal pavement where traffic is heavy and noise a detriment. Except for its high cost and a tendency toward slipperiness where wet it is suitable for streets with all degrees of traffic. Cost from $2.50 to $3.50 including grading. Maintenance cost from $.014 to $.26. It wears very evenly and has a life of from 10 to 20 years.

Advantages are noiselessness, long life, smooth, easily cleaned and sanitary. Disadvantages, tendency to slipperiness in wet weather and to bleeding and warping in hot weather due to improper treatment or laying.

Brick.—The type is good under all conditions as far as durability is concerned when made of a good quality product. It is noisy and should not be used where noise is a detriment. With lugs, it can be laid on fairly steep grades. It is not easy to broom but cleans readily with a flusher. Advantages, durability, slight resistance to traction, dustless and furnishes good foothold. Disadvantages, large coefficient of expansion, noisy, and tendency to edge wear producing cobbles and holes. Life with heavy traffic and car tracks, 8 years, without tracks 15 years. Costs $1.85 to $2.95 with a maintenance cost not generally exceeding $.02 per year unless it is treated with a bituminous coat.

Concrete.—Its life is not as long as that of brick but when properly constructed concrete is capable of rendering service fully commensurate with its cost of construction. Costs are quite modified by local conditions but generally average about $1.85 per square yard. Most of it would admit of resurfacing after 15 years. On several jobs in Illinois five year serial bonds, payable annually, were issued which gave a total cost at the end of a 25-year life, including first cost, interest and maintenance of $3.19 per square yard per year. Concrete is smooth, easy to clean and gives a good foothold when surfaced but is dusty, slippery and noisy without a bituminous coat.

Stone Block.—Is very good where the traffic is of the heaviest and most destructive type. When the blocks are so used they should be specially selected and tested. Granite and quartzite are usually used but the choice of kind should be governed by the availability. With a concrete foundation, well dressed and close jointed blocks of small size, a life of 30 years is not uncommon. The average cost with a grout filler is $3.50 per square yard with a maintenance of $.001 to $.02 per square yard. The pavement is durable, adapted to grades, and easy to clean when smooth but is slippery, noisy, rough and unsanitary when worn.

Tar Macadam.—This macadam has many advantages over water-bound, is less perishable, has a longer life, is practically noiseless, preserves a smoother surface and requires less maintenance. The cost is a little more than that of ordinary macadam but its increased life easily compensates for this, and it will take a considerably heavier traffic. It is not generally used on grades of over 1 in 30. Cost averages $.85 per sq. yd. with comparatively little maintenance. A patent of this type called Tarmac, using broken slag and tar mixed in a machine has been used to a considerable extent in England and has given good satisfaction.

Water Bound Macadam.—This is suitable for light traffic in residence districts when treated with a bitumen or light oil but without treatment soon ravels and becomes very dusty. Yearly maintenance is practically necessary at a cost of from $.04 to $.12 depending on the treatment. First cost depending on locality, varies from $.50 to $1 per square yard. Below are given the opinions of a group of prominent Canadian engineers as to:

I.—PLACE FOR PAVEMENTS (ARRANGED IN DESCENDING ORDER OF PRESENT POPULARITY).

(1) Light residence to semi-business: Sheet asphalt, bithulithic, asphaltic concrete, wood block, asphalt block, concrete.

(2) Semi-business to medium heavy traffic: Bitulithic, sheet asphalt, asphaltic concrete, wood block, asphalt block, concrete.

(3) Heavy traffic: Brick, wood block, stone, scoria block.

(4) Along street railway tracks: Wood block, brick.

(5) For quiet streets: Wood block, bitulithic, sheet asphalt, concrete.

(6) For graded streets: Brick.

II.—NATURE OF DETERIORATION.

Asphalt Block: Edge wear, forming holes and cobbles, noisy and hard to keep clean when worn, disintegrates at bottom.

Asphaltic Concrete: Wears into holes, susceptible to marking in hot weather.

Bithulithic: Wears evenly, tendency to holes under heavy traffic.

Brick: Edge wear and cobbling under heavy traffic, increased noise and unsanitariness as wear increases, slows down traffic when badly worn.

Sheet Asphalt: Wears slowly into large holes or patches, heavy traffic causes ruts, cracks hasten deterioration.

Wood Block: Rots if untreated, when treated wear is slow and even.

Stone and Scoria Block: Wears gradually into holes and cobbles, unsanitary when rough.

Concrete: Wears slowly and evenly if well made, otherwise cracks and chips.

Below are given various tabulations of comparison, compiled from data available:

I.—USUAL LIFE OF PAVEMENTS.—J. B. HITTEL, CHIEF ENGINEER, CHICAGO.

Asphalt	12 to 15 years
Brick	12 to 15 years
Wood block	15 to 18 years
Granite	30 to 40 years

II.—MOST ECONOMICAL PAVEMENT UNDER CONDITIONS.

(a) Large volume of heavy traffic.

(b) Secondary business streets with moderate volume and weight of traffic.

(c) Main city or suburban streets having large volume of light traffic.

(d) Suburban or residence streets where traffic is local and light.

For (a) macadam is most expensive, sheet asphalt slightly better than granite, but granite is preferable owing to the inconvenience of repairs to asphalt.

For (b) macadam is the most expensive, sheet asphalt the most economical.

For (c) granite is most expensive and a material difference exists in favor of sheet asphalt over macadam, though the relative costs do not differ widely.

For (d) granite is very expensive, macadam the cheapest.

III.—FRACTIONAL RESISTANCE.

Asphalt	1 (least)
Macadam	2-5
Macadam (wet)	7-8

IV.—COSTS FOR PERIOD OF YEARS, ASSUMING GRANITE HAS A 25-YEAR LIFE, WOOD 20 YEARS, BRICK 15 YEARS, ASPHALT 18 YEARS.

Material.	First cost per sq. yd.	Exp. per yr. per yd., 1st period.	Aver. exp. per yr. per yd., 50 yrs.
Granite	$3.50	$0.294	$0.270
Asphalt	2.00	.208	.164
Wood	3.50	.308	.274
Brick	2.50	.224	.199

V.—DURABILITY.

Material.	Small repairs. Years.	Extensive. repairs. Years.	Complete reconstruction. Years.
Asphalt black	5-10	10-12	12-15
Asphalt concrete	4- 6	6- 8	8-10
Bithulitic	5- 8	10-15	15-20
Brick	8-10	10-15	15-18
Concrete	5- 8	10-12	15-18
Stone—Scoria	10-15	15-20	20-30
Sheet asphalt	4- 8	10-15	15-18
Untreated wood	3- 5	6-10	10-12
Treated wood	8-10	12-15	15-18

VI.—GENERAL QUALITIES BY THE PER CENT SYSTEM.

Quality.	%.	Granite.	Wood.	Asphalt.	Brick.
Cheapness	14	8	8	11	11
Durability	21	21	16	15	16
Ease of cleaning	15	10	14	14	15
Light traffic resistance	15	13	14	12	15
Non-slipperiness	7	7	4	5	6
Ease of maintenance	10	10	8	6	6
Favorableness to travel	5	2	5	4	3
Sanitary qualities	13	9	13	12	10
Totals	100	80	82	79	82
Cheapness eliminated	..	72	74	68	71

VIII—GENERAL QUALITIES USING OTHER FACTORS.

	Per cent.	Granite.	Sand stone.	Sheet asphalt.	Block asphalt.	Brick	Macadam .	Wood.
First cost	14	4	4	6.5	6.5	7	14	4.5
Durability	20	20	17.5	10	14	12.5	6	14
Ease of maintenance	10	9.5	10	7.5	8	8.5	4.5	9.5
Ease of cleaning	14	10	11	14	14	12.5	6	14
Low traction resistance	14	8.5	9.5	14	13.5	12.5	8	14
Non-slipperiness	7	5.5	7	3.5	4.5	5.5	6.5	4
[1]Favorableness to travel	4	2.5	3.5	4	3.5	3	3	3.5
[2]Acceptability	4	2	2.5	3.5	3.5	2.5	2.5	4
Sanitary quality	13	9	8.5	13	12	10.5	4.5	12.5
Total	100	71	73.5	76	79.5	74.5	55	80

[1] Refers to smoothness and freedom from dust and mud.

[2] To noise, reflection of light and heat, emission of unpleasant odors and other things concerning pedestrians and adjoining residents.

In conclusion would say that many more years must pass and accurate data be kept before a reliable comparison of pavement can be procured. In any pavement construction, great attention must be given to the supply of materials at hand. Also, since prices are generally going upward, it must be taken into consideration that the increasing cost of construction and maintenance is not due alone to an increase in the amount of traffic, but to a necessary increase in cost of materials in years to come.

AN AMERICAN-MADE MASTIC SUBSTITUTE FOR IMPORTED ROCK MASTIC.

Contributed by D. T. Pierce, Executive Assistant, Barber Asphalt Paving Co.

"On account of the war" has become a household phrase in America. It is used to explain advances in the prices of commodities as well as our inability to get certain things at any price. But it is an ill wind that blows nobody good, and one advantage of the situation has been the development of a number of industries that will hereafter be independent of foreign sources of supply. We have also found that custom or habit, rather than economic necessity, has been responsible for considerable foreign trade.

The truth of the latter statement is clearly shown by our former large importations of rock mastic. It required the present cessation of imports growing out of the war to demonstrate that we are not only able to produce mastic in large quantities but of very superior quality. For a long time we imported from Germany—and in lesser quantities from Switzerland and Italy—many tons of rock mastic. But when importations suddenly ceased, architects and engineers found that the situation was really advantageous in so far as this particular material is concerned. They were at first concerned because mastic is used for so many purposes that to be deprived of it without being able to find a substitute would be a serious matter. But they know now that they can not only get a more uniform material than the rock mastic, but that it has been available for some time. That this change in the attitude of architects and engineers is important is shown by the extensive use of the material. It goes into the floors of storage plants, abattoirs, breweries, hospitals, bakeries, railroad stations and shops. It is especially valuable as a waterproofing material, being used in subways, bridges, piers and tunnels. The manufacture and use of the American product are already standardized. More than 75,000 square feet were used in the New York Municipal Building.

A curious fact is that while it was apparent we had a superior product, it is only recently that we discovered why it is better. Chemical research disclosed the fact that in the Trinidad Lake asphalt, which is the bitumen used in the American-made mastic, nature has supplied exactly the percentage of fine material content or filler required to obtain the best results. Analyses show no variation, whereas in the case of rock asphalt the filler and bitumen content varies from fat to lean. The Trinidad mastic has been developed largely by the experts of the Barber Asphalt Paving Co. A variation of the material ordinarily employed is an acid-proof mastic for lining tanks in which dilute mineral acids are employed.

PORTABLE STOREHOUSE FOR CEMENT.

Contributed by J. C. Worrell, Excelsior, Minn.

The portable canvas storehouse for cement, as described by Mr. Uhler in the issue of May 3, is a good one, but a storehouse of about the same size made of lumber and covered with tar paper would protect the cement better and be just as easily handled. Two 4x6-in. timbers could be placed under it for sills to support a floor and serve as runners to drag the house from place to place. One side and the top could be made so that either or both could be easily removed while filling or emptying the house. Where a team is not available for moving the house, lighter material may be substituted for the 4x6-in. sills, and the house made in six pieces fastened together with hooks. In moving from place to place, the house can be taken apart and set up again in a very short time.

Kansas City, Mo., will prepare to sell at once $1,150,000 bond issue voted last June for municipal improvements. It is expected that construction work on several of these projects will be started this spring. Work will include Twelfth St. Viaduct

PERSONALS.

Mr. L. A. Nicholson, in business as civil and consulting engineer for the past 26 years, has been appointed city engineer of Tacoma, Wash.

Mr. Laurent J. Tonnele of Bayonne, N. J., has been elected president of the North Jersey District Water Supply Commission. Mr. Nathan H. Pendergast of Jersey City is secretary.

Mr. Hubert Riley of Indianapolis, Ind., was recently appointed purchasing agent for the city. This is a new office which pays $4,000 annually. He will be succeeded on the board of works by Mr. Ernest Zeigler.

Mr. S. C. Cornwell, C. E., formerly city manager of Hickory, N. C., has been employed as chief engineer by Hawkins County, Tenn., and will superintend the construction of $450,000 worth of good roads for that county.

Col. John Biddle, Baltimore, Md., engineer in charge of the engineering corps of the U. S. Army in Baltimore, was recently appointed as new commandant of the U. S. Military Academy at West Point, N. Y. His duties will begin about July 1.

Mr. J. D. Kinnett of Macon, Ga., was recently elected water commissioner of that city to fill vacancy on board caused by the death of Mr. W. A. Huff. He has been engaged in the ice and coal business in Macon for the past twelve years.

Mr. Henry Gerharz, Helena, Mont., surveyor general, will hereafter make all surveys in Indiana reservations in order to standardize the surveys and make them uniform on all reservations. The work was formerly done by the geological survey.

Col. Harry Taylor, Albany, N. Y., of the corps of engineers, has been detailed as engineer officer in charge of Hudson river improvement work, with headquarters in New York. He succeeds General Wm. M. Black, who is now chief of engineers. His appointment will be effective July 1.

Mr. Stephen L. Selden has resigned as vice-president of J. G. White & Company, Inc., and has resumed the practice of law. He has associated himself with Hardie B. Walmsley and Francis L. Kohlman, heretofore the firm of Walmsley & Kohlman, at No. 61 Broadway. The new firm will practice under the name and style of Selden, Walmsley & Kohlman, and will have its offices at No. 61 Broadway, New York City.

OBITUARY.

Mr. Harlass K. Bachman, Kansas City, Kans., died May 13, at his home. He was a contractor for the last thirty years.

Mr. Charles Palmer, pioneer resident and founder of Imlay City, Mich., died at his home, May 14. He was born at Stillwater, N. Y., in 1831. For 12 years he was chief engineer and superintendent of construction of the Port Huron & Lake Michigan R. R., now the Grand Trunk West.

Mr. Geo. Neddo, Whitehall, N. Y., died May 13, at the age of 80 years. He was superintendent of the Champlain canal, section 3, for 16 years. He was born in Canada, but at an early age became a resident of Whitehall where he was engaged in boat building business. He had a record of building 300 canal boats.

Elmer L. Corthell, President American Society of Civil Engineers, died at Albany, N. Y., May 16, 1916, at the age of 76 years. An appreciation of Mr. Corthell's work is published on an editorial page. The list of the more important of these works are: Harbor Works—1875-80, Mississippi jetties; 1880-87, Tehuantepec ship-railway project; 1889-90, jetties, Brazos River, 1889-92, jetties, Tampico, Mex.; 1900, consulting engineer for Argentine Government on river and harbor work, Buenos Aires; Congress at Paris, paper on "Ports of the World"; 1902, president of Board to Report Plans for Port of Rosario; 1903-05, Works in Brazil, Buenos Aires, etc.; 1904, Advisory Board on Barge Canals for the State of New York. Bridges—Ohio River at Cairo; Missouri at Nebraska City and at Sioux City; St. Johns at Jacksonville; Mississippi River at St. Louis and the New Orleans project. Railroads—1881-85, New York, West Shore & Buffalo, Ontario & Western; 1890-93, "independent entrance" of railways in Chicago; 1892, Mexican National; Tehuantepec; rapid-transit and railroad problems in New Orleans, Atlanta, Montgomery, Chicago, Buffalo, Memphis and City of Mexico.

Mr. Wm. Stanley, Great Barrington, Mass., died at his home at the age of 58 years. He was a noted inventor and contributed largely to the development of the electrical industry. The electrical transformer and the alternating current system of long distance light and power transmission were among the most important of his inventions, forming the base of all present distribution of electricity. He was chief engineer of the Westinghouse Electric Company for three years, and was later head of the Stanley Electric Manfg. Co. and the Stanley Instrument Co.

Mr. Claud Clifford Conkling, chief civil engineer of the Lackawanna Steel Co., died May 8. Mr. Conkling was born in Rensselaerville, N. Y., Oct. 6, 1862. He spent his boyhood days at Scranton, Pa., and was educated in the public schools of that city. He continued his studies, including civil and mining engineering, and was first employed September, 1881, as rodman on the Erie & Wyoming R. R. and in a similar position during 1882 on water supply survey of the Ramapo Valley, N. Y. During 1882 and 1883 he took a special course of study at Williston Seminary, East Hampton, Mass. During the years 1884 and 1885 he was draftsman and transitman in an engineering office at Scranton, Pa., the work including a railroad survey in New Jersey, under J. H. Rittenhouse, C. E. Mr. Conkling entered the department of civil and mining engineering of the Lackawanna Iron & Steel Company in September, 1886, as rodman, and continued with that company (now the Lackawanna Steel Co.) in various capacities, as follows: April, 1888, transitman; September, 1892, assistant engineer; February, 1894, chief of department, since which time he had charge of the design and construction of all civil engineering work for the company. He had entire charge, for the first year and a half, of the construction of the company's plant at Buffalo, N. Y., the design and construction of railroad yards, sewers, villages, canals, harbor work, South Buffalo R. R. and foundations of all kinds during the construction of this plant. Mr. Conkling was chief engineer of the South Buffalo R. R., was chief civil engineer of the Lackawanna Steel Co. up to year 1904, at which time he left the direct employ of the company to engage in practice of consulting civil engineer, Buffalo, N. Y., during which time the surveys, plans and estimate were made for the Buffalo, Depew & Lake Erie R. R., a terminal freight railroad to be built around the City of Buffalo and other important work. In 1907 the original design of Lackawanna Steel Sheet Piling was patented. Mr. Conkling designed and patented modifications of the original design and was instrumental in bringing to a successful completion the designs and sections of Lackawanna Steel Sheet Piling now rolled by that company, also advising with engineers on many important projects in which this material was used. In October, 1913, the consulting work of this character had reached such a magnitude that Mr. Conkling returned to the Lackawanna Steel Co. as chief engineer in the steel sheet piling engineering department, which position he held until the time of his death. Mr. Conkling's long service with the Lackawanna Steel Company, faithfulness to duty and fairness to his associates, made for him numerous friends. His death will be a severe loss not only to them but to the engineering profession. Mr. Conkling was elected to membership in the American Society of Civil Engineers in the fall of 1904.

NEW CATALOGS.

Revolving Shovels.—Folder. Ball Engine Company, Erie, Pa.

"Bulletin S-14." Gives information on the Erie, Type B, ¾-cu. yd. revolving shovel.

Excavating Machinery.—Paper, 8½x11 in., 12 pp. The Osgood Company, Marion, O.

"Circular No. 14." Describes and illustrates the use of the Osgood 18 revolving shovel as a trench excavator.

Concrete Mixers.—Paper 7¾x9 in., 32 pp. Municipal Engineering & Contracting Co., Railway Exchange, Chicago.

Describes and illustrates the various types of Austin cube mixers. States advantages possessed by these mixers, and gives specifications of the different types.

Hoists.—Paper, 9¼x12 in., 10 pp. Lidgerwood Manufacturing Co., 96 Liberty St., New York.

"Bulletin No. 16." Gives data on the contractors' standard types of gasoline hoists made by this company. These include single, double and three friction drum types.

Motor Trucks.—Paper, 8x10 in., 28 pp. The United States Motor Truck Co., Cincinnati, O.

Describes the U. S. worm-drive and chain-drive motor trucks and illustrates their principal features. Also gives specifications of the different types, which range in capacity from 2 to 5 tons.

Autogenous Pipe Welding.—Paper, 8½x11 in., 52 pp. National Tube Company, Pittsburgh, Pa.

"Bulletin No. 26." Contains a rather exhaustive presentation of the subject of autogenous welding as applied to National pipe. The following subjects are covered in the bulletin: Welding in Gas Distribution; Welding Suburban Pressure Gas Mains; Welded Pipe Work; Oxy-acetylene Welding in Pipe Works; New Welded Gas Line at Newbern, N. C.; Efficiency of the Oxy-acetylene Welded Joint; Welding the Joints of Steel Gas Mains; Welding Large Industrial Mains in Chicago; Economics of Welded Pipe Connections; Gas Tight Joint in Steel Mains; Strength of Thermit Welded Pipe; Oxy-acetylene Welding and Cutting Costs; and Engineering Data and Information. The bulletin, which contains nearly 100 illustrations, will be found of especial value to users of steel pipe.

INDUSTRIAL NOTES.

The Austin Mfg. Co., Chicago, has received recently an order from the Russian Government for 146 road rollers. The machines are ordered in three different sizes, 8-ton, 10-ton and 12-ton. They are equipped to operate on Russian kerosene oil, the product of the vast oil fields located in southern Russia.

The Standard Brick Co. of Crawfordsville, Ind., has taken out a license from the Dunn Wire-Cut Lug Brick Co. for the manufacture of wire-cut lug paving brick. This makes 30 companies operating 48 plants now engaged in the manufacture of wire-cut lug brick. The Standard Brick Company is an established concern with a daily capacity of 25,000 brick, but it is enlarging its plant to a capacity of 35,000 brick daily with the necessary additional kilns to handle the output. The plant now has 7 kilns of 70,000 capacity each.

The Hill Machine Co. and the Hill-Tripp Pump Co. have, through consolidation, formed a new company, the Hill Pump Co., with headquarters at Anderson, Ind. The Hill Pump Co. has taken over all the assets and liabilities of the two parent companies, and furnished a large amount of additional capital. The Hill Machine Co. has been engaged in the manufacture of pumps for about 40 years, and the Hill-Tripp Pump Co. for the past seven years. The ownership of the consolidated companies remains practically the same. The officers are the same men who made the old companies what they were, and the general organization from the plant forces to the sales agencies will be retained, except for minor changes.

Engineering and Contracting

H. P. Gillette, *President and Editor*

Volume XLV. CHICAGO, ILL., MAY 31, 1916. Number 22.

ANNOUNCEMENT OF A WATERWORKS MAGAZINE PUBLISHED BY "ENGINEERING AND CONTRACTING."

For ten years this journal has devoted a great deal of space to articles on waterworks, and for six years has had a weekly section on that subject. The next step, which we are about to take, is to consist in devoting one entire issue (excepting as to contract news) every month to hydraulics. That issue will be known as the "Waterworks and Hydraulics Monthly," and will contain a great variety of articles—mostly short—relating to this important branch of civil engineering.

The subscription price for the 12 issues of this waterworks issue will be $1 a year. There will be three other "special issues" of "Engineering and Contracting" every month, each issue covering a certain branch of civil engineering. In this manner it is planned to give a special monthly magazine for those who desire only a monthly service in some one branch of civil engineering, but for those who desire to keep in touch with the entire civil engineering field a subscription for the weekly paper will serve in the future as in the past. Next week announcement will be made of the other three "special issues" that are to appear each month.

Contractors usually require a weekly news service and this they will continue to receive, but many engineers and superintendents require only articles. For the latter, a monthly service is often preferable to a weekly service, as a monthly service brings together a larger number of articles for perusal and comparison at one time.

There has been no monthly or weekly magazine devoted entirely to waterworks, if we except one "house organ." We have received a good many requests that we publish our waterworks and hydraulic articles as a special monthly on that subject, and we now plan to do so in the manner above outlined. The first issue of this new monthly service will appear July 12, and thereafter our Waterworks and Hydraulics issue will be published the second Wednesday of every month.

FLOOD CONTROL LEGISLATION IN CONGRESS.

The so-called flood control bill, which has passed the House of Representatives and is now awaiting action of the Senate, like other river and harbor legislation of the present Congress, is drawing severe newspaper criticism. The Chicago "Tribune" expresses the tenor of this criticism fairly well, in a recent editorial, as follows:

> The government will spend $45,000,000 or more on levees. (Engineers assert that the total amount will have to be $200,000,000 eventually.)
>
> Sixteen million acres of the richest land in the world will be reclaimed.
>
> The sixteen million acres, owned by private persons and syndicates of land speculators, will suddenly be worth a billion and a half or two billion dollars—well over $100 an acre, at any rate.
>
> These syndicates will not put on overalls and raise cotton crops; they will sell the land. They will not sell it at the price they paid for it, but at the price which $45,000,000 of the people's money has made it worth.

Whether these charges are wholly or only partly true, the occasion for them would be small were Government engineering works, administration and planning placed in the hands of a Federal Department of Public Works. Even the special commission plan of Representative Frear of Wisconsin would be a decided improvement over the present Congressional log rolling and pork barrel methods. But the "Tribune" and other newspapers which are so vigorously opposing these present methods should confine themselves to the non-technical features of the question or else secure engineering advice before discussing technical questions. The "Tribune" editorial from which the preceding quotation is made continues as follows:

> But even if the bill empowered the government to enforce a just distribution of the land it would not be a good bill. It is not at all certain that levees which are proposed will permanently reclaim the lands. The Mississippi River has been overflowing its banks for hundreds of years. It has overflowed because the channel of the river was too small to carry all the water to the gulf. Building levees means making the channel smaller. The amount of water remains the same. It is entirely within probability that a system of levees built without reference to control of the water at the sources will make the Mississippi rage the more. Levees may be overflowed and washed away.

To display in fewer words a greater ignorance of Mississippi flood conditions and levee action in flood control would be difficult.

LIQUID CHLORINE DISINFECTION OF WATER SUPPLY.

On another page we publish an article discussing important features of the liquid chlorine process of water disinfection. Within a very few years this process has gained unusual favor. It is comparatively inexpensive, it is not difficult to install and operate and it has proved its efficiency. Efficiency studies in detail are however lacking. This is owing in part to the youth of the process and in part to the fact that in most places where it has been used it has been installed as an emergency or precautionary measure. The writer of the article published in this issue discusses a question of detail in efficiency. His article is therefore of unusual interest as indicating that liquid chlorine disinfection is about to enter upon the stage of its service where refinements of method will be evolved. We commend this discussion to our readers engaged in supplying water for potable purposes.

CITY CO-OPERATION TO SECURE MUNICIPAL INFORMATION.

Eight months ago there was organized in New York a State Bureau of Municipal Information. This bureau is financed by the cities of the state, a general law enacted in 1916 giving cities this power. The established appropriations are: For first class cities $500, for second class cities $300, and for third class cities $150. There are in the state three cities of the first class, seven cities of the second class and 48 cities of the third class, and all but eleven cities of the third class support the bureau by appropriations. By the end of the present year it is believed that the remaining eleven cities of the third class will have joined the others. During its eight months actual service the bureau has sent to the cities of all classes, not excepting the eleven which gave no financial aid, 1,239 reports. Its operating expenses for these eight months have been $4,879.

The nature of the accomplishment of this bureau is best indicated by mentioning representative examples of service rendered. We quote from the bureau report:

> It has researched and prepared and issued reports on 146 general municipal subjects. Several of these are voluminous. It calls particular attention to the reports on municipal house-cleaning. These consist of reports on the method and cost of collecting and disposing of ashes, garbage and manure in and by American cities; also a report on street-cleaning methods and cost. The Bureau has compiled the water rates of all cities in the state and the cost and method of

> street lighting in all Empire state cities. It has prepared reports giving the salaries of all city officials in each municipality in the state, and for one city it prepared a report giving the salaries on 175 different officials in 28 of the 50 largest cities in the United States. It has tabulated the experiences of many American cities which have used wood block and bitulithic for paving. It has compiled information showing how American cities pension their policemen and firemen and how they regulate various activities by ordinance. It has ready for distribution a compilation of the different traffic regulations in the principal cities of the United States. It has prepared reports about the experience of cities with various methods of sterilizing water, repairing brick pavement. steel and concrete bridges, public markets and their regulations, night schools to teach foreigners the English language, care of charity patients by private hospitals, various forms of municipal government, municipal piggeries, insuring public buildings, waste collection by motor trucks, municipal electric light plants, oiling streets and the various methods used, methods of selecting assessors, municipal subways, women on police force, assessing the cost of ornamental street lighting, municipal infant welfare stations, two-platoon systems for fire departments, municipal clean-up campaigns, paving by municipal forces, assessments, bond issues and tax rates. It also has prepared reports on the cost of different kinds of pavement laid in New York state cities last year. It has gathered and has ready to loan to any city in the state the blank forms used by American cities in purchasing supplies through a central agency. The forms used by American cities in securing departmental estimates for budget making, forms used by police departments in making various reports, and forms used by investigators in charities departments of American cities. In addition to this general research work, the Bureau has done considerable special work for individual cities.

The preceding outline gives information of an uncommon practice in American municipal administration. It has been and is the general practice of American cities to consider all municipal problems as individual problems despite the fact that the greater number of these problems are general and a common practice is in large measure possible. The result has been excessive duplication of effort and expense. For example two cities sought knowledge say of prevailing pavement costs. Each instituted search by correspondence and library work. Both obtained, substantially the same information. Two expense accounts were involved, the labor of two sets of men was engaged, each city answering the request for aid wrote two letters giving duplicate data. Multiply these two cities by many scores of cities throughout the country which each year make such searches and an idea of waste energy and money is had. The co-operative plan eliminates the greater part of this waste. The report of the bureau being considered states this fact forcibly as follows:

> As a result of this co-operative plan each city in the state is receiving a needed service which it could not possibly duplicate by individual effort and for the money it pays. The experience of the first eight months has convinced us that the Bureau has been able to get more quickly, accurately, easily and economically information about cities and city problems both in and outside the state than any individual municipality could. This has been demonstrated many times. One city wanted a copy of a valuable publication issued by an Ohio municipality, but was informed by the mayor that none was available. The New York state mayor then appealed to the Bureau, which within a week sent the book to him. To secure the data for the report on the cost and methods of collecting and disposing of garbage the Bureau sent a three-page questionnaire to all New York state cities and to the 50 largest cities in the United States. Every city responded giving the Bureau a 100 per cent return for its effort. We attribute the success of the Bureau in this respect to the fact that when it makes a request for information each city realizes that the information it sends is for the benefit of all municipalities in the state of New York. One answer to an inquiry from the Bureau serves at least 57 cities, and will serve every city in any state which has a state league co-operating with us.

The closing sentence of this quotation offers a suggestion of multiplication of state leagues of cities each with its Bureau of Municipal Information which deserves encouragement.

AN EXAMPLE OF DELAYED LOCK AND DAM WORK.

Last week we mentioned editorially some of the reasons why Government lock and dam construction is in bad repute among contractors. One of these reasons was the risk due to uncertain river conditions. As indicating an extreme example of this risk we quote the following paragraph from a published account of lock construction on the Cumberland River:

> There were practically no delays due to breaks in the plant and practically no interference in the operation of the various units of the plant system. The arrangement was simple and dependable, and this feature of the work is emphasized because contractors so often make trouble by having an unbalanced plant layout, where one piece of plant is expected to accomplish too much. The contractors spared neither effort nor expense to make a favorable showing with this work; they did make excellent progress, as the lock was practically completed the first year of the contract. In their efforts to hasten the completion of the lock walls the first year the contractors failed, however, to complete the rock excavation in the lower approach. This is due to the fact that the first and, as yet, the only period of extreme low water was not used to accomplish this work. The result is that after three years' effort, in which the greater part of the work was accomplished the first year, the contractors are still awaiting a favorable opportunity to complete the rock excavation in the lower approach. It is probable that this work will not be completed within the contract time.

The most that can be charged against this contractor is fault in judgment in choosing the part of the work that should be completed the first year. Here there would seem to be an instance "where latitude given the contracting officer in interpreting specifications" would be a desirable thing.

COLLOIDS IN ENGINEERING STRUCTURES.

Colloidal chemistry is not new but the word colloid still has a foreign sound in the ears of most civil engineers. We have begun to hear of the colloidal action of Portland and natural cements, and now we are learning something about the colloids in asphalt pavements.

Colloids are particles of matter about one-four-millionth of an inch in diameter. They remain indefinitely suspended in liquids and swim about in almost life-like manner, endlessly oscillating with amazing rapidity.

Certain rocks, notably shales and limestones, are rich in colloidal matter, and it has been known for some years that such rocks made a water-bound macadam possessing greater cementing quality than the silicious rocks.

Recently Mr. Clifford Richardson has discovered that Trinidad asphalt is particularly rich in colloidal matter, and has advanced the theory that this accounts largely for the excellence of that kind of asphalt for paving purposes. The colloidal particles have the property of causing relatively thick films of asphalt to adhere tenaceously to their surfaces. The thought is thus suggested that colloids are not only cementitious themselves but have a marked effect on other cementitious matter, at least in so far as to cause a physical change in its distribution in a mixture.

EDITORIAL PARAGRAPHS.

Is there in Pennsylvania a town named King of Prussia? There is. It is in Montgomery County and has 888 inhabitants. Recently a residence near the town caught fire. A messenger on horseback brought the alarm to the King of Prussia Volunteer Fire Department. The Department responded promptly but there was no water supply. A small stream half a mile away was dammed, two pumps were installed, a hose line was laid and water was being played on the fire by the "time the roof had fallen in." Salutations to the K. of P. V. F. D.; it has the record of installing a complete force supply system and putting it in operation during a fire. The house burned but it was a darned good try.

While reviewing the water supply locals of our exchanges we may also note that installation of meters at Riverhead, Long Island, has jumped water bills to an excessive amount. The trouble, according to press clipping, was discovered to be:

> Plumbing out of order and the water running right through from the big tank providing an unlimited quantity of water at an 80-lb. pressure to the river into which empty the sewers. Two important discoveries were made. The first, that an astonishingly large amount of water can pass through a small leak in a day, and the second, the reason why there have been but few tides low enough in the river this winter so that the head of the house could catch a mess of clams to help keep down the high cost of living.

A campaign for paper conservation is being inaugurated. Paper prices are soaring higher than are warring aeroplanes. Indeed the paper makers warn us that the "world confronts a paper famine." Engineers and the engineering industries are large users of paper. They are urged to economize; cut down the size of house organs, use half sheets for short letters, limit circularization, sell old paper instead of burning it. Some of these things are good things to do whether paper is or is not scarce.

The metric system advocate is a most persistent individual. At the present moment there is a bill before Congress providing that anyone using after 1924 other than metric weights and measures shall be fined $300 or imprisoned three months or both fined and imprisoned.

"Russia is a world's timber supply," says a recent magazine article. The thought is worth a moment's time. Here are the figures: Of its 8,500,000 square miles, 39 per cent is forest. Including Siberia the Russian Government itself owns 900,000,000 acres of woods.

The ordinary linotype machine with which this line-of-type has been set carries about 180 characters. The excuse for announcing this fact is the news that an inventive Japanese has perfected a corresponding device to set mechanically the 5,000 characters in use by Japanese and Chinese printers. The consular agent who reports this news says: "The machine to some extent looks like a model of Brooklyn Bridge." Since the keyboard of an ordinary linotype is about 14x8 in., the consular agent may not be exaggerating.

Ability to write a concise report logically arranged and clearly presented is an accomplishment which the engineer should acquire even at much pains. At Stevens Institute of Technology beginning with the last school year report writing is made a requirement for graduation. One-half day a week for half a year is the time allotted. We should like to see the period extended over the whole of the junior and senior years and four reports required instead of one.

From a recent lecture of the many lectures on military engineering now being offered the civil engineer, we take the following statements:

> Military engineering, in contrast to civil, consists of makeshifs and temporary expedients. The commanding general does not ask, "How much will it cost?" but, "How soon will it be ready?" Rough and ready makeshifts are the triumph of the military engineer. He must use any material at hand. The bridge, for instance, must be ready day after tomorrow. Unlike a civil community, the army cannot wait. Methods as to speed constitute a study no engineer can afford to neglect.

Incidentally the last statement is also wholly true in civil practice.

A discussion on how to hold good help was in progress at the conference of the Boston Employment Managers' Association when a member arose and said: "All you gentlemen are talking on holding help. For heaven's sake tell me where to get some. I'm hiring anything that wears pants." This harassed individual epitomized the unskilled labor situation.

Asserting dogmatically as fact something of whose truth one is uncertain is often provocative of information. In bridges the North American continent now possesses the longest arch span, the longest simple span, the longest draw span, the longest cantilever span and the longest continuous span. Are we disputed?

While on the thought of long bridge spans, a question often propounded by the curious layman is: How long a bridge span can be built? Steinman gives the answer as follows: Simple spans can, theoretically, be constructed up to 1,960 ft. by using nickel and high carbon steels. Theoretically suspension spans can be built up to 14,700 ft., practically up to 4,900 ft., and economically up to 3,170 ft. Cantilever spans are theoretically possible up to 5,600 ft., practically up to 3,060 ft., and economically up to 2,700 ft.

CONSIDERATIONS IN DETERMINING THE POINT OF APPLICATION OF LIQUID CHLORINE IN THE DISINFECTION OF WATER SUPPLIES.

Contributed by Francis F. Longley, Hazen, Whipple & Fuller, Consulting Engineers, New York, N. Y.

Liquid chlorine like its forerunner hypochlorite of calcium has come into rapid recognition during the past few years for the disinfection of water supplies. Since its first application on a working scale to a municipal supply less than five years ago, several hundred installations have been made throughout the country. The low cost of this treatment compared to any more complete purification such as filtration, its demonstrated efficiency, and the simplicity of its installation and application, have resulted in its rather hasty adoption in many cities. With the newness of the process, the lack of experience in its use, and the scarcity of precise knowledge regarding the chemistry of chlorine when used in this way, there are many considerations now recognized which could not have been taken into account a few years ago, in the design of a liquid chlorine equipment.

The question uppermost when an apparatus was to be purchased seems to have been, "will it work? Will it deliver the disinfecting agent into the water in a regular, dependable way?" Upon the showing of the first striking experiments on the use of liquid chlorine, it was generally accepted, subject to certain recognized limitations, that the disinfectant would always produce a reduction in numbers of bacteria; and therefore, while bacterial reduction has been the primary object of this method of treatment, it seems that in many cases this has been left subservient and considerations of physical or engineering convenience have determined the point of application.

It would be interesting now to examine these numerous installations in detail and study the conditions which led to these various points of application. It is not feasible to do this, but a review of some of the conditions now known that are likely to control the location of the point of application may be of interest.

This discussion was intended primarily to relate to the liquid chlorine treatment. In many of their phases the treatments by liquid chlorine and by hypochlorite are so much alike, that experience with both of them yields light upon the conditions under discussion; and so far as the essential points are covered thereby, occasional reference may be made to hypochlorite.

For a consideration of this question, all installations may be divided into two classes. First, in those installations in which disinfection is the only treatment which the water receives, the location of the point of application will be determined by physical or hydraulic conditions. Second, in the installations in which disinfection is an adjunct to some other more complete treatment, such as filtration, not only physical conditions, but also conditions arising from the proximity or inter-relation of the two forms of treatment, must be considered.

Based on physical conditions existing at the point of application, liquid chlorine equipment may be considered under two heads: first, with the application made as a solution; and second, with the application made as a gas. These two methods of application give rise to conditions which have an important effect upon the selection of the point of application.

If the chlorine gas is mixed with water before reaching the actual point of application to the supply, the flow of this solution must of course follow the laws of hydraulics. The solution of the chlorine in the water is generally accomplished in an absorption tower or tank of some kind located at or about the elevation of the chlorine tanks and other apparatus. The absorption tower is in most cases open to the air, and the flow therefrom into the supply is commonly by gravity. There are a few installations in which this solution is pumped into the supply, but the pumping of such a liquid is a bothersome procedure, and is usually avoided if possible.

If the solution is to be delivered into the supply without pumping the absorption tower must stand near enough and high enough above the hydraulic gradient of the supply into which it is delivered to afford free gravity flow. This arrangement can in most cases be conveniently secured by putting the solution into the suction of a pump or into an open suction well or conduit. It does not in general permit the delivery into a closed conduit or pipe under pressure, unless some means is provided for pumping the solution against that pressure.

This is perhaps the most common point of application, and it has the advantages of convenience and of thorough agitation and mixing of the treated supply as it passes through the pumps.

There has frequently been some concern felt over the question of corrosion in the pump, due to the introduction of a corrosive substance like chlorine into the water just before it enters the pumps. When the use of hypochlorite was comparatively new, there were a number of cases noted of corrosion of pumps, but they were the exception rather than the rule, and may have been due to excessive application with imperfect apparatus, or some other accidental cause. Experience through several years past with liquid chlorine indicates that there is no real danger from this. The mechanical absorption of the gas by the water seems to be so prompt and so complete that it does not have an opportunity to act upon the metallic surfaces of the pump, or pipes.

There are a few installations in which the liquid chlorine is applied, in the form of a chlorine solution, on the discharge side of pressure filters. This is accomplished by utilizing the drop in pressure through the filters. The supply of water for the absorption tower is taken from the main supplying the filters. The absorption tower, instead of being open to atmospheric pressure, as is usual, is completely closed, and under substantially the pressure of the supply main. A head practically equal to the loss of head through the filters is then available to deliver the chlorine solution from the absorption tower into the pressure main on the discharge side of the filters.

There is a limitation to this fixed by the minimum pressure to which the chlorine tanks can work. It is perhaps sufficient to state that the application could not be made as above described if the pressure prevailing in the discharge main from the filters much exceeded 40 or 45 pounds.

If the application of chlorine is made to the water supply as a gas, there is no point in the apparatus at which the pressure of the gas drops to atmospheric pressure. The tank pressure as reduced in a pre-determined way by pressure reducing valves is available to deliver the gas into the supply. The tank pressure must not be permitted to fall, due to chilling from too rapid vaporization, below about 54 lb., or troubles result from the refrigerating effect produced. With some allowance for loss of pressure through the apparatus, it is therefore possible to deliver the gas into the supply from this tank pressure against a considerable water pressure. A water pressure of 35 lb. is commonly stated as the limit against which a gas may be thus applied, but cases are on record of application against pressures somewhat higher than this.

These cases, however, may require that artificial heat be applied at times in order to keep the tank pressure at a point high enough to accomplish the delivery as stated.

With this limitation, the chlorine may be applied as a gas, into a water main under some pressure. It may be applied at an elevation considerably higher than the elevation of the tanks and the control apparatus. It may be conveyed through pipe a distance probably considerably greater than the distance to which the chlorine solution could be carried. There is therefore much greater latitude in the selection of the point of application when the chlorine is to be applied as a gas, than as a solution.

The condition of distance is sometimes met by separating the absorption tower from the tanks and measuring apparatus. The chlorine can then be carried as a gas to any reasonable distance and discharged into the absorption tower, which in turn can be so located as to facilitate the discharge of the solution into the supply.

Another condition may be mentioned here which may affect the type of apparatus and therefore the point of application in many small supplies. The chlorine when delivered into the supply as a gas is measured through an orifice, when a difference in pressure is maintained on the two sides of the orifice by means of pressure control valves. The size of an orifice which will deliver say 25 lb. of gas in 24 hours, under the head commonly used in this apparatus, is very small. This is equivalent to about 0.3 parts per million of chlorine in a ten-million gallon supply. If the total quantity of gas supplied in a day is much less than this, the orifice becomes so small that it becomes increasingly more difficult to keep it clean and delivering at a uniform rate as an orifice should. The size of the orifice which will deliver 1 lb. of gas in 24 hours is so small that it will no more than permit the entrance of the point of a fine needle. For a quantity of gas as small or smaller than this, some other device must be used for its measurement. Orifice meters are now in use delivering quantities down to a minimum of about 1 lb. per twenty-four hours in the gaseous state, but for total daily quantities smaller than that, the devices in use involve the formation of a solution of the gas. The conditions and limitations described above for the application of a chlorine solution to the supply, therefore, must apply to any supplies which require such small quantities of chlorine as were just mentioned.

When the chlorine is applied in a gaseous state, it is commonly distributed into the water through a porous diffuser of some kind, which delivers it as a mass of extremely small bubbles, of chlorine. Chlorine gas bubbles thus set free in water tend to rise to a fairly constant velocity of about 24 ft. per minute. It has been found in practice that the bubbles arising from the diffusers commonly used become completely absorbed by the water before they have risen about 4 ft. on the average. This will vary somewhat with the quantity of gas set free at the diffuser, but 4 ft. is commonly looked upon as sufficient depth of submergence for an apparatus delivering normal quantities of gas. For this type of apparatus a point of application must therefore be found which will have at all times a suitable depth of water.

Ordinarily no difficulty is encountered in this matter. It occasionally happens, however, that a fluctuating water level, at the point of application may at times reduce the depth of water over the diffuser below the limit mentioned. A proposal to apply the chlorine as a gas under these conditions would contain some elements of risk, involving possible loss of gas, the escape into the air of corrosive chlorine, and a reduction in efficiency of the treatment. It might at times be difficult to find an alternative location readily accessible where the conditions of depth of water would be at all times suitable for the application of chlorine as a gas. Under such conditions, the choice would be presented of applying the chlorine as a solution where a small limit of depth was immaterial, or of seeking a more perfect but perhaps more inaccessible location for the application of the chlorine as a gas.

Where disinfection by liquid chlorine is the only form of treatment used, the difference in bacterial efficiency, at different possible points of application, is likely to be unimportant. Where used as an adjunct to filtration, however, the efficiency may be quite different for different points of application.

The use of liquid chlorine is sometimes claimed to, but cannot be depended upon, to reduce in any degree any of the other objectionable contents of a water supply. The reduction of bacteria was the primary reason for the development of this process, and therefore, bacterial efficiency may be considered the factor of foremost importance.

Where disinfection is used as an adjunct to filtration, the ideal point of application is in general after filtration. The efficiency of liquid chlorine as a disinfectant is influenced by the presence of color and turbidity and by other substances dissolved in the water. A water that contains considerable quantities of turbidity or color requires a much larger dose to produce a given bacterial removal. The quantity of liquid chlorine required to produce a satisfactory final result is therefore much less if the application is made after the turbidity of color is removed by the filtration treatment. This may be considered one of the phases of an ideal treatment.

It sometimes happens that the application in the filtered water results in objectionable tastes or odors. Waters differ in their susceptibility to trouble of this sort. With some waters the dose of chlorine that is required to give the desired bacterial results is also enough to leave a taste. With others there is a safe margin between these two limits.

When the former conditions prevail, it is desirable to apply the chlorine after filtration, but before the water goes to the filtered water reservoir, as storage is an important factor in the dissipation of any tastes or odors that may result from the treatment.

This consideration is less important where tastes and odors give no trouble. In a great many plants now in service, the application is at a point beyond which there is no detention except in the mains, before the water reaches the consumer. Conditions are not constant, however, and there may be times with most supplies when tastes and odors may be detected. It is desirable, therefore, in every case in which it can be arranged, to apply the chlorine to the water before it goes to the filtered water reservoir.

In the early days of disinfection of public water supplies, there was in many places a prejudice against the application of a chemical of any sort, especially of a chemical with the supposed highly corrosive properties of chlorine or hypochlorite, to the water after it had passed through the filters. A filter operating efficiently was considered to be as near the acme of perfection as could reasonably be attained.

This prejudice arose from the fear that objectionable tastes and odors might result if the water were treated with a disinfectant just before being delivered to the consumer, and also the fear regarding turbidity that might be contributed by the sludge when hypochlorite was used. It is true that tastes and odors have sometimes been conspicuous, but longer experience and broader acquaintance with liquid chlorine treatment has resulted in a great reduction in difficulties of this kind, and this prejudice has been quite overcome. Now the filter effluent is considered quite generally the ideal point of application for the chlorine.

In a number of cases the application of a disinfectant has been made just before the water was applied to sand filters. In some of these cases the results have been disastrous to the bacterial efficiency of the filters. The reasons for the application at this point are not now clear, but these cases occurred several years ago when the treatment was new, and those who chose the point of application could hardly have foreseen what the results would be.

The application resulted at first in a very good reduction in numbers of bacteria. This was followed within a short time by a large increase in the bacteria in the effluent, the numbers there being even much greater than the numbers in the raw water. This condition of affairs persisted for some time until the cause of the trouble was perceived and the application of disinfectant discontinued at that point. The restoration of a normal bacterial efficiency to the filters took some time, and the subsequent application of the disinfectant to the water after filtration produced the desired results. The reason for this appears to have been the destruction, either partial or complete, of bacterial life in the schumtz-decke on the filter, with its subsequent decomposition which afforded food material for the prolific growth of organisms. The removal of this purifying agency, and the presence of this food material encouraged the appearance of large numbers of bacteria in the effluent.

This trouble arose from the fact that the disinfectant was still in an active state when it reached the surface of the sand. It is commonly considered, with good supporting evidence, that the chlorine acts very promptly in reducing the bacteria after it is applied to the water. There are certain lines of evidence, however, such as the above, which indicate that all the reactions resulting from the addition of chlorine to the water are not complete for some little time after its application. There is no evidence at hand to show how long this time is. There are a number of plants, however, in which the application of a disinfectant is made as the water enters a coagulating or settling basin, just preceding filtration. No deterioration of the filter as a result of this application has been recorded, which leads to the belief that in these particular cases the time of storage after the disinfection treatment and before the water reaches the filters has been great enough to permit the completion of all the reactions that result from the addition of the disinfectant.

In a number of cases liquid chlorine is applied to a supply just before it is pumped into pressure filters. With filters of this type primary dependence is not placed for the bacterial purification upon the presence of a living organic schmutz-decke. It may be, therefore, that the above remarks do not apply to this condition, but there is room for suspicion that the bacterial results following the treatment arranged in this way may not be all that they should be.

Some claims have been made that a saving could be effected in the quantity of alum required with a mechanical filter if liquid chlorine were applied before filtration. The study of this question has been rather limited. There are a few ardent advocates of this belief, and it is possible that in some cases a saving may have been accomplished. So far as it is true, this condition also will affect the point of application.

Economy is many times a consideration in the location of a liquid chlorine equipment. The apparatus must be housed. A pumping station or gate house or other building is usually located conveniently, but it sometimes happens that this location will not facilitate the application in the ideal way. When this condition of affairs exists, it has frequently happened that rather than build a new building especially to house the liquid chlorine equipment at the ideal point, it has been located in an existing structure in the hope that the results of the treatment will be just as good at that point.

The question of availability of a supply of water for the solution of the chlorine often influences the point of application. The convenience of the determination of the rate of flow in the main or conduit to which the chlorine is to be applied, in order properly to adjust the dose, is sometimes an important factor in fixing this point.

It is unfortunate that data are not more generally available to show definitely the relative advantages or disadvantages of these points, especially with reference to the bacterial efficiency which results, and to the quantity of disinfectant that has to be applied. Efforts that the writer made a year or so ago to get comprehensive information along these lines indicated only that systematic observations are not commonly taken to determine the efficiency and the economy of this treatment.

PUMPING WATER FOR IRRIGATION.

Contributed by Louis Schmeer, Irrigation Engineer, Colton, Cal

The Well.

That the art of sinking wells was practised by the inhabitants of Egypt in very remote times is attested by the artesian borings in the Oases of Thebes, Garb and Siwah (the ancient Jupiter Ammon), north of the Lybian desert. Most of these wells are estimated to be over 4,000 years old. The historian Strabo, (64 B. C.-19 A. D.) who traveled in Northern Africa, says, that the Egyptians had both bored and walled wells. Olympiodorus, writing at the beginning of the fifth century states that in the oasis in which he was born (Thebes), wells bored to a depth of 950 ft. had an overflow sufficient to allow the cultivation of extensive tracts of land. The ancient wells in Siwah, amongst them the celebrated well of Apollo, the sun god, today have such an abundant flow that they sustain groves containing over 200,000 date palms, a population of 6,000, and besides feed numerous ponds and lakes.

In Europe the first attempt at deep boring of which any definite record has come down to us was successfully completed in 1126, nearly 800 years ago, on the coast of Flanders; the object being to tap the deeper strata of the coastal plain for water of greater purity than the brackish supply found near the surface. At Liller in Artois, the Roman Artesia, a well of 1126, is still flowing. In 1150, deep borings were also made at Goslar, in the Hartz mountains, Germany. The deep salt well at Soden and others are known to have been in existence before the 30 years' war. In 1713 Bartels in Zellerfeld invented a rock boring machine used in prospecting for salt and metals. The Chinese are known to have bored for water, brine and gas 2,000 years ago. One of their Ho-Tsing (gas well, fire well) to the southwest of Khiang-Tshen is reported to have burned from the second to the thirteenth century. Their method of sinking wells—rope boring—was first brought to the knowledge of the Western world by a report of the Dutch ambassador Van Hoorn, published in the 17th century. In 1829 the French missionary Imbert[*] published the first complete description of the method and it at once was introduced into the coal fields of Belgium and Germany.

The rapid growth of the industrial centers of England after the close of the Napoleonic wars stimulated the prospecting for both water and minerals by means of deep borings. From England the impetus spread to Continental Europe, the Atlantic slope of the U. S., and, with the conquest of Algiers by the French, to northern Africa. The best known borings of this period are the celebrated fountains of Bud Nauheim, Germany (1816-1838) and the artesian well at Grenelle, in the basin of the Seine, France (1833-1844). The most noted well driller of this period was the Saxon mining engineer Kind who invented the crown drill and the free fall instrument. This ingenious technician made an offer to the city of Paris, then in quest of an increased water supply, to sink a well surpassing the one at Grenelle both in diameter and delivery. A boring 3.6 ft. in diameter was started at Passy, a suburb of Paris, in 1854. In 1857, after the boring had reached a depth of 1,682 ft., the casing was crushed in by a stratum of clay occurring at a depth of 100 ft. This mishap delayed progress for 32 months and the well was not completed until 1861. Its depth is 1,896 ft. and its diameter at the lower end 2 ft. Its flow is gradually diminishing and is at present about 8.65 sec.-ft.

During the progress of the sinking of these wells boring methods and appliances were much perfected. A perusal of a publication of this period (1865) reveals the fact that tools and types of casings now considered as of very recent origin were then in common use.

The deep borings gave the savants and hydrologists an excellent opportunity to study water bearing formations and trace the movements of underground waters. To the lucid intellect of one of these, Dupuit,[†] we are indebted for the fundamentals of our present day knowledge of underground flow.

Movement of Ground Water.—In the surface layers of the earth's crust water may be present in the form of groundwater, capillary water or hydroscopic water. Of these only the first moves under the action of gravity and enters the problem of the flow of wells.

The quantity of groundwater a material is able to absorb depends upon its porosity; the rate of movement of the absorbed water, however, upon both the porosity and the size of the pores. In their upper layers the materials of all geological formations are practically more or less porous and water may be present as far down as pores exist. The porosity of the crystalline rocks is however even at the surface so small that no water can be obtained from their body. The average porosity of the granites is about 1 per cent, that of the slates and shales 4 per cent. In many situations the upper zones of crystalline formations are, however, traversed by numerous cracks of sufficient dimensions to allow the passage of considerable quantities of water. In the granites the vertical cracks are usually 10 to 20 ft. apart; they are most numerous and of greatest dimensions near the surface and entirely vanish at depths between 400 to 500 ft. At irregular intervals the vertical cracks are traversed by horizontal or inclined seams which are the closer together the less the depth. If a well in a crystalline formation is not to be a "miss," the boring must either follow a vertical crack or else intersect a horizontal or inclined seam.

In crystalline beds exposed to wind and weather the storage of water in cracks and seams is soon exhausted, much of it ascends through capillarity to the surface and is evaporated. The supply is more abundant and lasting if the formation is covered by a stratum of loose material which acts as a feeder. The nature and depth of such a feeder is of the greatest importance. It determines both the quantity of flow into a well, as well as its permanence.

Limestone formations usually have two sets of vertical cracks, intersecting each other. The porosity of the limestone varies between 5 and 15, that of the sandstone between 5 and 35 per cent. Lime and sandstones of the most recent formations are generally sufficiently porous to yield good quantities of water. All of the sedementary rocks, the slates, shales, lime and sandstones have water bearing seams following their regular bedding planes.

Of the unconsolidated materials the clays are the most porous, but owing to the extreme fineness of their texture, gravity movements are almost entirely absent, they yield no water and beds of these materials are practically as impervious as walls of granite or slate.

The porosity of the silts, sands and grits decreases with increasing diameters of the soil grains; they part with their water the easier, however, the greater the size of the pores. The porosity of the clays and adobes varies between 50 and 60, that of the sand and gravels between 25 and 35 per cent.

In ground water movements the accepted unit is a flow of 1 cu. ft. per square foot of percolating surface per day. This unit is called the transmission constant and is usually denoted by K.

From tables of factors given by Slichter the contributor finds that the equation for the constant K may be written:

$K = 22{,}464\ P^{3.3}\ D^2\ (0.7 + 0.03\ T\ C^{\circ})$, in which P = the porosity of the material; = the voids divided by the volume.

D = the effective diameter of the soil grains in millimeters.

$T\ C^{\circ}$ = the temperature of the water in degrees centigrade.

The effective diameter of the soil grain is defined as that of the largest soil grain in a mass containing the 10 per cent of soil grains of the material having the least diameters. The resulting value of K holds good, however, only in case the diameter of the largest soil grain in a mass of 60 per cent of the material containing the soil grains of the least diameters does not exceed five times the effective diameter as defined above. The number 5 is called the uniformity coefficient. This proviso serves to eliminate materials in which cobblestones, boulders, etc., are embedded. Table I gives values of $22{,}464\ P^{3.3}$ for the most common porosity percentages, from which, having the effective diameters, values of K are readily computed.

TABLE 1.

P	$22464\ P^{3.3}$.	P	$22464\ P^{3.3}$.
0.01	0.01	0.34	638.5
0.05	1.14	0.36	771.5
0.10	11.25	0.38	922.0
0.15	42.9	0.46	1,092
0.20	110.8	0.425	1,334
0.25	231.5	0.45	1,611
0.26	263.7	0.475	1,925
0.28	337.6	0.50	2,280
0.30	422.5	0.55	3,125
0.32	561.6	0.60	4,164
0.333	598.6		

The factors given in the table indicate that the transmission capacity is increased ten times in case the porosity is doubled.

---

[*] Imbert, Annales de la Propagation de la Foy, Paris, 1829.

[†] Dupuit: Le Mouvement de l'Eau dans les Terraines permeables. Paris, 1846.

According to the U. S. Soil Survey the diameters of the loose materials are as follows:

Description of material.	Diameter in millimeters.
Clay	0.0001-0.0005
Silt	0.005 -0.05
Very fine sand	0.05 -0.10
Fine sand	0.10 -0.25
Medium sand	0.25 -0.50
Coarse sand	0.50 -1.0
Fine gravel	1.0 -2.0

The effective diameter of the grains of a sandstone varies to a great extent with the depth of the stratum, the layers composed of the coarsest grains occurring in the deepest zones. This in general also holds good for unconsolidated sand and gravel strata. The effective diameter of the grains of a specimen of Potsdam sandstone found near the surface proved to be equal to 0.056, that of a specimen found at a depth of 20 ft. equal to 0.20 millimeter. The mean effective diameter of the grains of the Dakota sandstone is about 0.10 millimeter. The mean values of K. for the Dakota and Potsdam sandstones are nearly the same and equal to about 9.5. Which means, that 9.5 cubic feet per square foot of percolating area filter per day through an average specimen of the materials mentioned, provided the flow is vertical and the temperature of the water 10° C.

The mean porosity of the material in a stratum of coarse sand or fine gravel is usually in the neighborhood of 33 per cent and the mean effective diameter of the grains varies between 0.5 and 0.8 m.m. Hence K varies between $600 \times 0.5^2 = 150$ and $600 \times 0.8^2 = 384$.

The best of the wells in the granites yield about 35 gal., those in the slates about 50 gal. a minute. Single wells in these formations will consequently not yield water in quantities worth while for irrigation purposes. In localities where the value of water is very great a group of such borings provided with inexpensive pumping devices and provision for storage might, however, merit serious consideration.

The yield of wells in crystalline formations has been closely investigated by Klapp and Fuller. The quantities of flow given in Table II, abstracted from a paper read before the New England W. W. Association, by Fuller, may serve as a guide in estimating the probable flow of wells in the materials mentioned.

TABLE II.—YIELD IN CUBIC FEET PER DAY OF A WELL 8 IN. IN DIAMETER AND 100-200 FT. DEEP.

	Cover on rock.		
Material and location.	Absent.	Medium.	Heavy.
A. Granites—			
Wells on slopes or hills	960	2,304	4,800
Wells on plateaux or upland plains	1,152	4,608	5,950
Wells in valleys	1,920	5,760	5,730
B. Horizontal shales and slates, joints poorly developed—			
Wells on slopes or hills	.....	480	1,152
Wells on plateaux or upland plains	.....	960	1,920
Wells in valleys	.....	1,536	2,880
C. Inclined shales and slates, jointing well developed—			
Wells on slopes or hills	.....	1,920	5,760
Wells on plateaux or upland plains	.....	2,688	7,680
Wells in valleys	.....	3,092	9,600

For calcareous shales and slates add about 25-50 per cent.

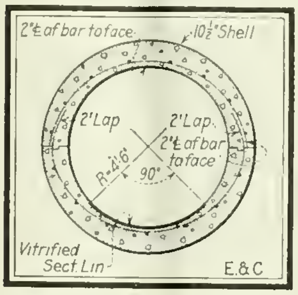
(To be continued.)

STORM SEWER CONSTRUCTION AT DAYTON.

The first of several large storm sewer jobs proposed by the city of Dayton, O., is now ready for bids. The work advertised calls for the building of what is known as the Dry Hollow Creek Storm Sewer. This will begin at Wolf Creek and Western Ave. and extend westward on Michael St. to Baker St. From here it turns southward on Baker St. to Second St., and thence westward on the latter street to Church St. The improvement involves the construction of 4,700 ft. of 9-ft. circular sewer. The trenching will require about 47,000 cu. yds. of excavation. The depths of trench for the 108-in. sewer are as follows:

9-ft. sewer lin. ft.	Depth trench, ft.
40	10-12
54	12-14
95	14-16
781	16-18
1,844	18-20
542	20-22
251	22-24
113	24-26
454	26-28
201	28-30
20	30-32
5	32-34

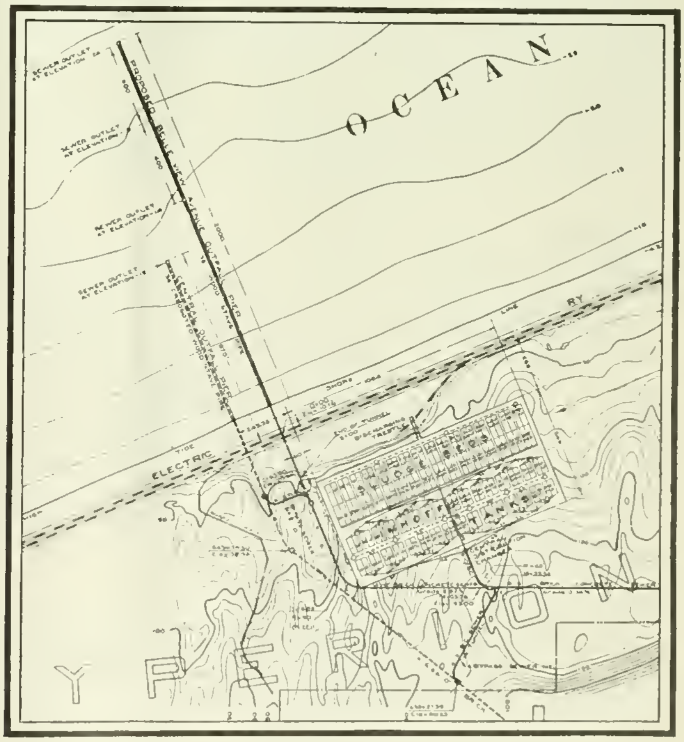
The plans call for 1,700 ft. of monolithic concrete sewer 1:2½:5 mix with a 12-in. shell and 3,000 ft. of reinforced concrete sewer, 10½-in. shell. Both of these sections will have vitrified sectional lining in the inverts. The accompanying drawing shows a section of reinforced concrete sewer. The transverse reinforcement for this will consist of ¾-in. square twisted bars, 12-in. centers. The longitudinal reinforcement will consist of ½-in. square twisted bars approximately 24-in. centers. There will be 82 lbs. of reinforcement per lineal foot of sewer.



Alternate proposals will be received on 4,700 ft. of 108-in. reinforced concrete pipe sewer and 4,700 ft. of segmental block sewer. The total estimated cost of the improvement, including engineering, inspection and contingencies is $110,000. Bids will be opened June 7 by J. S. Barlow, director of Public Service. F. O. Eichelberger is City Engineer of Dayton, O.

A $1,800,000 SEWAGE DISPOSAL DEVELOPMENT FOR LOS ANGELES, CAL.

Preliminary plans have been prepared by the Engineering Department of the city of Los Angeles, Cal., for the betterment of sewage disposal conditions at Hyperion and Los Angeles Harbor. At the present time 42,000,000 gal. per day of sewage is discharged into the ocean at Hyperion in a crude condition. It is proposed to treat the sewage and plans have been made for a disposal plant of a size to provide for a population of 1,000,000.



General Plan of Sewage Disposal at Hyperion.

The plan proposed for Hyperion provides for the installation of a plant consisting of a series of settling tanks of the Emscher type and a series of sludge beds. The clarified liquid matter will be discharged from the end of a new outfall pier into the ocean at a distance of 2,000 ft. from shore and at a depth of 18 ft. below mean sea level. The effluent will be discharged at three different places on the line of the pier.

The general plan of sewage disposal at Hyperion is shown in the accompanying illustration. The development also calls for the improvement of sewage disposal conditions at San Pedro, East San Pedro and Wilmington.

It is proposed to treat and dispose of the sewage of San Pedro at Point Fermin. The plan calls for the construction of a sewer to extend from the northerly end of the city to the Point, intercepting all the sewage now discharged along the water front in San Pedro. In order to accomplish this result it will be necessary in two places to install a pumping plant and force main to collect sewage from low areas. The sewage from this intercepting sewer will be treated in a series of Emscher settling tanks to be located near the junction of the breakwater and the main land. The effluent from this plant will be discharged through an outfall sewer laid along the bottom of the ocean to a point about 2,400 ft. east of the mainland. The plant is designed for the disposal of sewage from an ultimate population of 39,000.

In East San Pedro the sewage of Terminal Island is to be disposed of by pumping from a central point through a force main to a disposal site in the southeast corner of Fish Harbor. The work at this place will include a considerable rock fill and the construction of a plant consisting of two Emscher settling tanks. The plant also is designed to provide for the sewage from the industrial section of East San Pedro and to provide for an ultimate population of 2,500. In order that this industrial section may be sewered, it will be necessary to install an additional pumping plant near Fish Harbor.

At Wilmington it is proposed to construct a second unit at the disposal plant in order to provide for the sewage which is now discharged in a crude condition, at the foot of Fries Ave. and Canal Ave. An intercepting sewer also is required. It is estimated that the population to be provided for after the installation of the second unit will be 5,400. A pumping plant will be installed in Manchester Ave. for handling the sewage in that portion of the Florence Ave. sewer district lying east of Vermont Ave. and south of Florence Ave.

The estimated cost of the improvements is $1,800,000. An election will be held on June 6, at which the citizens will vote on issuing bonds to construct the work. Homer Hamlin is City Engineer of Los Angeles; W. T. Knowlton is Engineer of Sewers.

THE POLLUTION OF NEW YORK HARBOR AND ITS REMEDY.*

Of the five largest cities of the world, New York alone—the greatest of these—has no system of main drainage and sewage disposal. Its 316 square miles of territory are drained, as a rule, by direct lines to the nearest points on its 580 miles of water front, where some 300 outlets discharge 550,000,000 gal. of sewage daily into the waters of the harbor without treatment, from 2,000 miles of sewers. The strong tidal currents of the East river, the large volume of upland water from the Hudson and the great extent of the bays furnish almost ideal conditions for the dilution of sewage; but as the ratio of sewage to harbor water has increased, conditions have become less favorable until now a serious nuisance may be apprehended during hot weather at certain points.

Studies of the pollution of the harbor have been carried on almost continuously since 1903, by the N. Y. Bay Pollution Commission, by the Metropolitan Sewerage Commission (Dr. G. A. Soper, president), by Col. W. M. Black and Prof. E. B. Phelps for the Board of Estimate and Apportionment and more recently by the Bureau of Sewer Plan and the Board of Estimate itself, of which Nelson P. Lewis is chief engineer and Arthur S. Tuttle, deputy chief engineer. These studies have included the formulation of plans for sewage disposal to secure and maintain what may be termed a decent degree of cleanliness in this important harbor and have comprised the following lines of work.

Inspections were made of the debris found along the shores of the areas of sleek and visible pollution near outlets and of the pollution of public baths by sewage effluents which had been colored by a strong dye (uranine).

Analytical work consisted in many chemical microscopical and bacteriological tests of the waters of the harbor. Of these the determination of dissolved oxygen was found most illuminative. Fig. 1. It was found that while the waters of the open ocean were practically saturated, the percentage of oxygen decreased with the approach to the city until in the Lower East river and Harlem river it was very low and in the Gowanus Canal it was frequently absent. These tests were made by the Metropolitan Commission and have later been supplemented by the Bureau of Sewers of Manhattan (C. E. Gregory, Chief Engineer) and the Bureau of Sewer Plans.

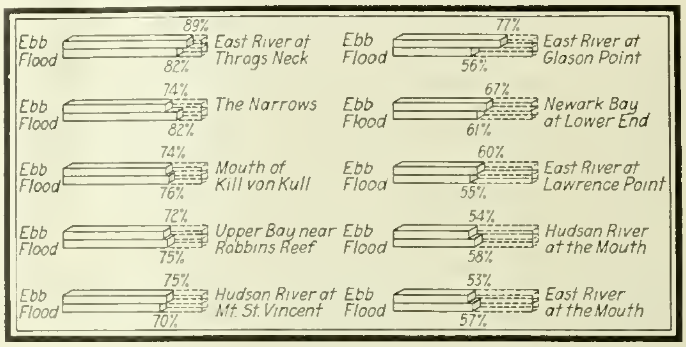


Fig. 1—Dissolved Oxygen Arranged for Flood and Ebb Currents.

MINIMUM PERCENTAGES OF DISSOLVED OXYGEN.

	1909.	1911.	1913.	1915.
Lower East River	56	51	11	19
Harlem River	21	19	11	0

It is the minimum degree of saturation, which occurs in the hot weather of late summer, that is most significant, as it is this that indicates the approach of a serious nuisance, such as has been experienced in the past in the Thames, the Seine, Baltimore harbor and Bubbly Creek, Chicago. Residents can testify to the detriment such conditions entail and their effect upon real estate values.

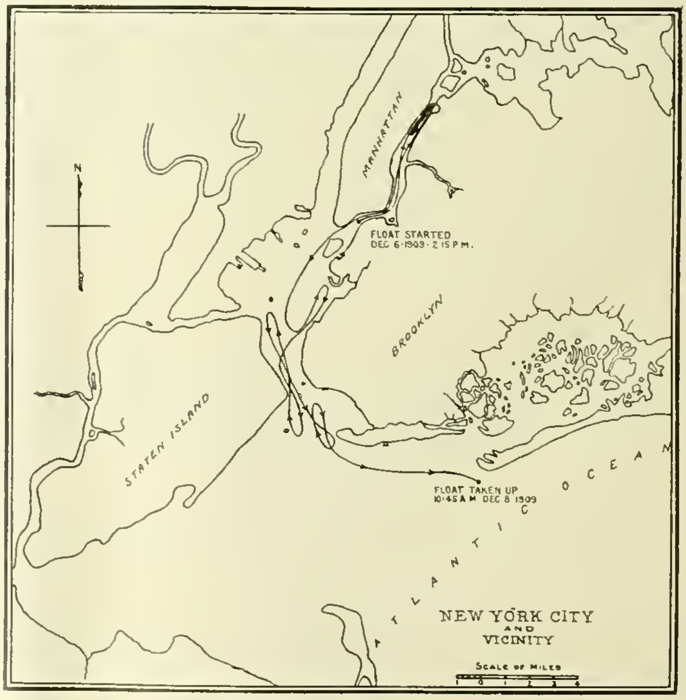


Fig. 2—Flood Movement.

Tidal currents in New York harbor, upon which dilution largely depends, are varied and complex. Valuable information, hitherto in part unpublished, was furnished by the U. S. Coast & Geodetic Survey. This was supplemented by numerous float experiments and solinity observations (Figs. 2, 3) made by the Metropolitan Commission furnished an excellent measure of the mixing of sea and upland water by the tides and stream flows. Of particular interest was a series made Apr. 13-15, 1909, between the eastern end of Long Island Sound and New York Upper Bay (Fig. 4).

---

*Abridgement of paper read before the Connecticut Society of Civil Engineers by Kenneth Allen, Engineer of Sewage Disposal, Board of Estimates and Apportionments, New York City.

PERCENTAGE OF SEA WATER.

Greenport Harbor	90
Smithtown Bay	80
Throgs Neck	70
Williamsburgh Bridge, New York	60
Governor's Island, in New York Upper Bay	34.8

This decrease toward the west furnished the best evidence of a resultant tidal flow in that direction. Otherwise the waters near Throgs Neck would more nearly partake of the character of those in the Upper Bay. This point had never been definitely settled by gagings.

Fig. 3—Testing Salinity of Water in Ambrose Channel Light Ship. Fig. 5—Diffusion Experiments Pumping From Pontoon to Depth of 40 Feet.

The flow from the harbor to the ocean amounts to 1,282,000,000 cu. ft. per tidal period of 12 lunar hours, mostly due to the discharge of the Hudson, and in an important element in the capacity of the harbor to receive sewage and dispose of it.

Diffusion experiments were made to observe the effect of a discharge of sewage into harbor water. These were carried out in the laboratory, at the N. Y. Aquarium and in the open waters of the harbor. To show the effect of salinity 30 c.c. of sewage colored with 1/10,000 part of uranine was discharged from a pipette on the surface of 3,000 c.c. of water in a Mason jar. With tap water, diffusion began in a few minutes and was complete in an hour; with 25 per cent sea water it was not complete until 48 hr.; with 50 per cent sea water it took 56 hr., and with 75 per cent sea water it remained incomplete at the end of a week. This brought out the advantage, so far as diffusion is concerned, in discharging sewage into fresh water.

One of the most interesting of the Aquarium experiments consisted in the discharge of colored sewage into fresh water from a ½-in. jet under a head of 0.15 ft. in a horizontal direction at a depth of 3.4 ft.—near the bottom of the tank. The sewage first spread out in the form of a blanket about 2 in. thick over the bottom and then, in about three minutes, began to diffuse. Within about a half hour diffusion was complete. This illustrated clearly the tendency of sewage to remain near the bottom if discharged horizontally into fresh water. In sea water it rose rapidly in the form of a cone and spread out in a thin sheet on the surface.

At the proposed location of the Passaic Valley Sewer outlet in the Upper Bay a 1:500 solution of uranine pumped through a 1¼-in. hose to a depth of 40 ft., when the Spec. Grav. of the water was 1.020, rose to the surface. In another test at this point 56,000 gal. of tap water containing 290 lb. uranine were pumped from a pontoon through an 8-in. pipe to a depth of 40 ft. at a rate of 2,320 gal. per minute (Fig. 5). The velocity of the stream was 0.45 ft. sec. at a depth of 3 ft. and 2.85 ft. sec. at a depth of 50 ft., and the temperature of the water was 72°. In spite of the large volume discharged it could not be discovered at the surface. It was concluded from these experiments that an effluent will rise or fall, depending solely on the relative specific gravity of the two liquids. In sea water it rises promptly, while in fresh water it will remain at the level of the outlet or fall. Immediately after discharge diffusion begins this decreases with the salinity but probably bears some relation to the volume or surface of contact between the two liquids and increases rapidly with an increase of current.

Visible Evidences of Pollution were noted by numerous inspections of the shores and waters of the harbor. Sludge deposits causing bubbling were found near outlets and in many slips; feces and other evidences of sewage were generally noted near outlets, and in the Lower East River, at times, from shore to shore, sleek and oil scum from trade wastes were common and the water was visibly clouded for long distances from sewer outlets.

When one considers that New York is one of the great ports of the world, that most of our foreign immigrants and tourists arrive here, while a vast population arrives at New York daily by vessels from domestic points, and then thinks of the greater comparative cleanliness of the harbors of London, Glasgow, Hamburg and Rotterdam, the importance of improving these conditions in New York harbor is manifest.

A standard of cleanness was given much thought by the Metropolitan Commission and others and in essentials the views of the different authorities were in harmony except as to the dissolved oxygen, for which saturations of from 70 to 20 per cent saturation or less were recommended. But as a general proposition I think it may be said that, with the exception of the Harlem River, if the visible impurities are removed and the oxygen maintained at the figures which now obtain in the main channels, no serious objection can be found; but to accomplish this the general treatment of effluents will have to be introduced and the existing sludge deposits along the water front removed.

The harbor waters are an important agency in sewage disposal and if diffusion were perfect there would be little reason to apprehend trouble through putrefication. Any oxidizing treatment is therefor not likely to be required except to a limited extent—perhaps near the head of Jamaica Bay.

The general mode of treatment will probably be by settling or fine screening in order to remove visible solids and those which cause deposits. The precise relative efficiency and cost of these two processes yet remains in doubt; but it may be said in general that tank treatment will usually remove a larger percentage of solids. It is hoped that more definite information regarding fine screening will be available within the next two years so that a selection between the two may be made with more confidence than at present. Meanwhile the policy is to plan for screening where the elimination of the larger visible solids is sufficient while settling plants will be placed where the oxygen is in danger of falling too low. Although the public is hardly yet aware of the urgency for carrying out systematic improvements to ameliorate the general conditions in New York harbor, the city authorities and those experts who have looked into the matter, are in complete agreement that at least:

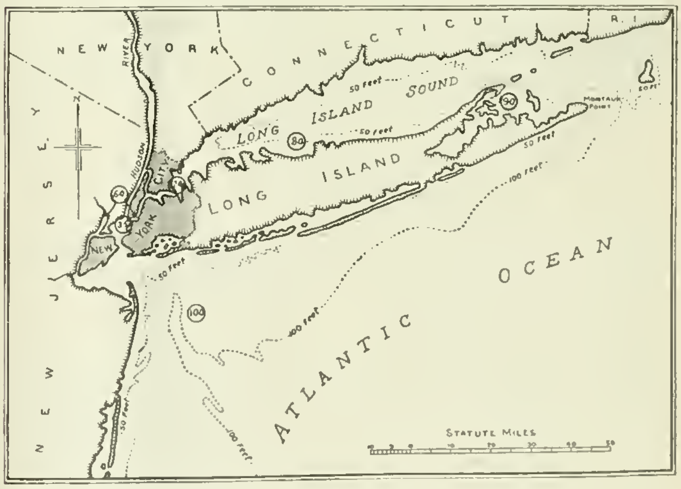


Fig. 4—Percentage of Seawater in Long Island Sound and the East River.

1. Visible evidences of sewage pollution should be prevented.

2. Sludge deposits should be, so far as practicable, removed and prevented.

3. A comprehensive plan to protect the harbor from any increased pollution should be prepared at this time, subject to modification, to which all plans for main drainage and sewage disposal shall conform.

Probably no more thorough investigation of harbor pollution has been made than in the case of New York. It has been approached from every possible viewpoint and passed upon by not only the many experts called in by the Metropolitan Sewerage Commission and the City and State of New York for this purpose, but by many more who presented testimony for or against the Passaic Valley Sewer project in the recent suit before the U. S. Supreme Court. Within a generation a population of 12,000,000 or 14,000,000 will be tributary to the harbor—more than twice the present number. The importance of forestalling the unsavory situation that would certainly arise if a laissez-faire policy were permitted in the meantime was well expressed by Prof. W. T. Sedgwick, who said, in a report to the Metropolitan Commission: "I wish it might be possible for your Honorable Board to convince the people of Metropolitan New York, as I am convinced, that no investment, however great, would be too large to secure the complete and perpetual conservation of these waters for purposes of health, of pleasure and of agreeable and attractive commerce. Nor is this condition merely an iridescent dream. A sum such as is already set apart for clean, pure drinking water for the metropolis would go far toward making this a reality. . . ."

HIGHWAY CONSTRUCTION IN WASHINGTON BY CONVICT LABOR.

The honor system of working convict labor on highway construction in the state of Washington was first used in 1913. The following notes on the results obtained are taken from the last biennial report of the State Highway Commissioner. On Sept. 10, 1913, 30 honor men were placed in the first camp 1 mile north of Hoodsport. A second camp was established 2 miles south of Kalama on Dec. 3, 1913, for the construction of a portion of the Pacific Highway south from that city. Honor Camp No. 1, having completed the work assigned to it on the Olympic Highway was transferred on July 14, 1914, to Skamania County as Camp No. 3 for work on State Road No. 8, from Stevenson west. On July 27, 1914, Honor Camp No. 2 was likewise transferred to Stevenson as Camp No. 4.

All camps were of light frame construction, with the exception of the men's quarters at Camp No. 1, on Hood's Canal, where tents were provided. Owing to the dampness of the climate during the winter months the use of tents for quarters has been abandoned. In addition to receiving 50 ct. for each day's labor, the men were fed, clothed and sheltered in sanitary quarters at the expense of the State.

All employes of the camps were honor men with the exception of the superintendent, his foremen and such special skilled labor as is necessary to carry on the work to the best advantage. The camp clerks also were free men with the exception of Camp No. 4, where an honor man has been used to advantage, as both Camps No. 3 and No. 4 were under the same general superintendent.

The disposition of the honor men toward the system was, in general, very favorable. The table below shows that a comparatively low percentage failed to uphold the trust placed in them.

	Camp No. 1.	Camp No. 2.	Camp No. 3.	Camp No. 4.
Total number different honor men	49	50	50	53
Number returned to penitentiary as undesirable	1	4	1	0
Percentage of returns	2.04	8	2	0
Number of deserters	1	2	3	1
Percentage of deserters	2.04	4.0	6	1.9

Honor Camp No. 1.—Olympic Highway.—The work on the Olympic Highway during the winter months was carried on under the most unfavorable conditions—conditions which no contractor would have ventured to face. The road is located on the steep mountain side just above high tide along the west shore of Hood's Canal. The excavation work during the winter months was entirely in earth. The earth which is classified as common excavation, is a material composed of a mixture of soil and gravel, resting on a cemented gravel or hardpan foundation, which slopes towards the road and water's edge. Owing to the porous nature of the soil and the impervious foundation below, a large amount of surface water is retained, thus causing many slides. During the winter months these slides were a continual source of expense. Great quantities of soft earth intermingled with trees, stumps, and brush would come down on the road, and in some instances destroy the finished roadbed.

When the conditions would permit, the men worked even though it rained, with comparatively little ill feeling toward their position. At times the material became so soft that it would run from the shovels and resemble mortar more than earth and the men sank half way to their knees in the mire. During the month of January it rained continuously for 25 out of 27 days and working under such unfavorable conditions, the best of efforts accomplished but little, much time necessarily being lost. As the cost of maintenance was a constant factor, the result for the winter season was a poor showing for the money expended when compared with the results of the summer months or with contractor's work executed during the summer season. As wet weather does not interfere with rock excavation as much as earth work, the unit price would have been materially reduced had it been possible to work such material during the winter months and have left the earth work for the dry summer season.

The average daily number of honor men maintained in the camp was 25.7; 3.4 miles of previously constructed road was opened to traffic and .75 miles of new road constructed.

Honor Camp No. 2.—Pacific Highway.—About the same general conditions surrounded this work as that on the Olympic Highway, but the excavation was in different class of material and slides did not interfere with the progress of the work. Over half of the excavated material was solid rock and could be handled more economically during the wet weather than the earth. A daily average of 29.7 honor men were maintained in the camp; 1.08 miles was constructed and 1.9 miles cleared and grubbed at a net cost of $11,471, and the unit costs compare very favorably with that for similar contract work executed under more favorable weather conditions.

The classification of the net expenditure is as follows:

Classification.	Camp No. 1.	Camp No. 2.
General expense:		
Common free camp	$ 1,710.96	$ 1,742.19
Common convict camp	491.59	244.94
Subsistence	3,581.99	2,973.41
Clothing and shoes	965.78	1,011.77
Transportation	489.48	420.88
Medical and surgical	212.99	303.85
Salaries and wages:		
Free	1,364.68	1,106.97
Convict	2,894.75	2,722.67
Tools and equipment	358.61	424.78
Powder and blasting supplies	545.61	520.01
Totals	$12,616.44	$11,471.47

The net unit costs and quantities for the various classes of construction at Honor Camps No. 1 and No. 2 are given in the following table:

	Camp No. 1		Camp No. 2	
Item of work.	Quantity.	Unit cost.	Quantity.	Unit cost.
Common excavation, cu. yd.	16,374	$0.446	4,698	$0.304
Loose rocks excavation, cu. yd.	259	.645	1,364	.559
Solid rock excavation, cu. yd.	1,512	1.02		
Clearing, acres	7.54	110.18	9.2	112.43
Grubbing, acres	2.84	174.20	2.64	155.67
Riprap, hand placed, cu. yd.	....	....	10	.984
Concrete, cu. yd.	11.11	6.17	65.05	7.33
Reinforcing steel	....	....	....	*27.70
Cribbing, logs, per sq. yd.	484.8	1.71	....	....
Culvert, logs, lin. ft.	58	1.04	....	....
Culvert, concrete, diameter 12-in., lin. ft.	260	1.90	220	1.63
Culvert, concrete, diameter 18-in., lin. ft.	....	....	28	1.85
Culvert, iron pipe, diameter 24-in., lin. ft.	64	2.55	....	....
Culvert, iron pipe, diameter 36-in., lin. ft.	40	3.14	....	....
Wood box drain, lin. ft.	99	.174	....	....
Finishing	....	*348.43	....	....
Brush cribbing, cu. yd.	100	1.76	....	....
Log rail, lin. ft.	255	.111	....	....
Overhaul, 400 ft. limit	....	....	6,498	.017

*Total, not unit cost.

The actual cost of the construction by convict labor has herein been stated in detail. The penitentiary, however, has been saved the cost of maintaining these men and when such saving is taken into consideration the costs as herein given should be proportionately reduced.

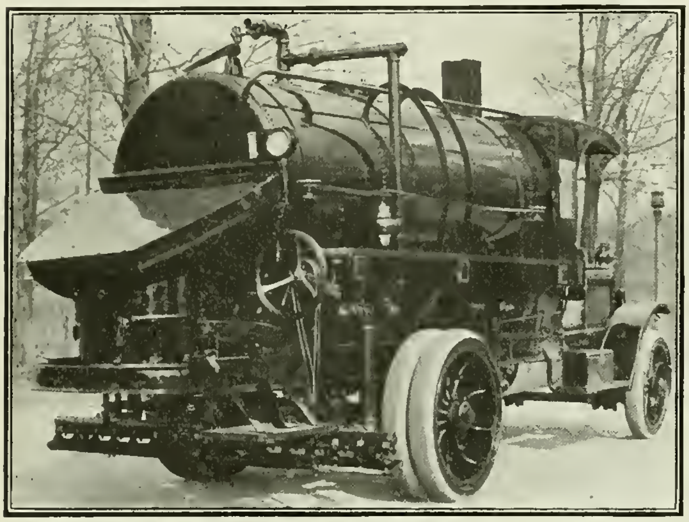
Some of the detail costs under the honor camp system as observed at Camps No. 1 and 2 are as follows:

Classification.	Camp No. 1.	Camp No. 2.
Subsistence per man per day	$0.412	$0.395
Equivalent wage per day (including clothing, medical, transportation, subsistence, items of general expense, bedding, etc., and 50c cash wages)	1.494	1.423
Cost of maintaining institution per convict, per day, exclusive of materials placed in the roads	1.974	1.92

COMBINATION ROAD MAINTENANCE AND CONSTRUCTION TRUCK.

(Contributed.)

The new combination maintenance and construction truck illustrated embodies in one compact unit facilities for performing road work that formerly required several individual pieces of special road machinery. The truck can be used for flushing and sprinkling streets, applying heavy or light oils to roads, either hot or cold, or spreading hot asphaltic oils to a road surface under a penetrating pressure. When the truck is not needed for road work the iron tank that holds the liquids may be quickly detached and the truck used with an ordinary body for general haulage purposes.



White Combination Truck for Road Construction and Maintenance.

Two of the chief features of the new truck are the high temperature possible with the patented heating system and the duties performed by the rotary displacement pump. The pump is driven by a lay shaft from the rear of the truck transmission case. Oil or water may be taken into the tank at the top or by using the pump to force it in through an intake pipe at the front. In loading the tank direct from freight cars the truck need not be on a lower level than the cars, because the pump has a lift of 13 ft. While the oil in the tank is being heated the pump keeps the liquid in constant circulation, carrying it out of the top of the tank down through a pipe at the side and back into the bottom of the tank. This agitation keeps the heavier oils from settling on the bottom of the tank and becoming thick or gummy. It also helps to heat the liquid in a much shorter length of time. After the oil has been turned off at the distributing nozzles in the rear of the truck the pump carries the oil remaining in the pipes back into the tank and an automatic drip trough falls, preventing any leakage of the oil to the street. This is especially advantageous in passing street crossings.

The heating system eliminates the need for separate heating plants, erected alongside the freight cars or by the road. It will raise the temperature of a tank full of material at the rate of one degree a minute and maintain 350 degrees steadily. It is located in a separate section on the rear of the tank and heat is distributed uniformly to every one of the regular boiler flues, located in the one-third lower section of the tank. The old method of placing flash burners in a false section of the tank frequently overheated the flues nearest the burners, igniting the liquid and causing it to overflow.

The distributing nozzles, sixteen in number, are located in the rear of the tank and operated by a man from a small seat on the right side and end of the truck as shown in the above illustration. They cover a strip of road 8 ft. 6 in. wide, but if desired, they may be moved to the right or left of the center a distance of 2 ft. The nozzles throw a fan-like stream, one overlapping the other and insuring uniform distribution to the road while the 80-lb. pressure delivered by the pump drives the liquid down into the crevices, binding it firmly. Three sets of nozzles are furnished for different grades of work. The pressure gage and the thermometer for the heating system are within view of the operator on the rear seat and he regulates them. A double bell system enables him to communicate with the driver of the truck while it is in motion.

There are two sizes, a 3-ton chassis, 45-HP. motor and 800-gal. tank or a 5-ton chassis, 45-HP. motor and 1,000-gal. tank. The tanks are made of heavy steel, hot riveted and calked inside and out. The 1,000-gal. size is 48 inches in diameter and 10 ft. 6 in. in length.

After the tank has been used for oiling it can be quickly cleaned by using the pump to circulate kerosene through it. A small tank of this cleaning fluid is attached to the left side of the truck. In flushing the pump delivers 300 gal. of water per minute and covers a strip of road from 8 to 12 ft., while the sprinkling nozzles cover from 20 to 40 ft. This truck is made by the White Co., Cleveland, O.

COST OF SHEET ASPHALT AND BRICK PAVEMENTS AT MONTREAL, QUE.

During 1915 approximately 600,000 sq. yd. of sheet asphalt and 500,000 sq. yd. of brick pavement were laid in the city of Montreal, Que. The average unit costs of these pavements were as follows:

SHEET ASPHALT.

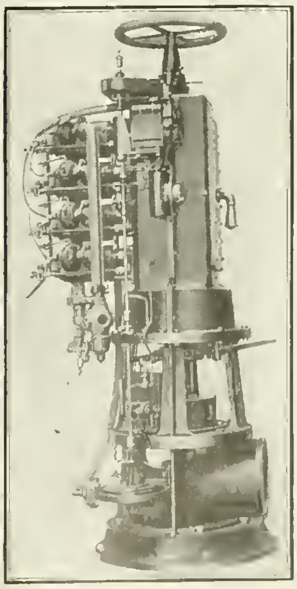
	Earth work.	Foundation.	Surface.	Total.
Labor	$0.4945	$0.2917	$0.0892	$0.8754
Material	.....	.6149	.5367	1.1516
Sundries	.0371	.0441	.0195	.1007
Total	$0.5316	$0.9507	$0.6454	$2.1277

BRICK PAVEMENT.

	Earth work.	Foundation.	Surface.	Total.
Labor	$0.4945	$0.2917	$0.4762	$1.2624
Material	.....	.6149	1.7824	2.3973
Sundries	.0371	.6441	.0499	.1311
Totals	$0.5316	$0.9507	$2.3085	$3.7908

The foundation consisted of 6 in. of 1:3:6 concrete. The asphalt paving was composed of 1-in. binder and 2-in. wearing surface. Paul E. Mercier is Chief Engineer of Montreal.

A VERTICAL GAS ENGINE DRIVEN DEEP WELL PUMP.



The illustration shows a notably interesting independent deep well pump unit. As shown, a multi-cylinder oil engine much similar to an automobile engine, is direct connected to the centrifugal deep well pump shaft. The engine may be operated by gasoline, kerosene or any of the low grade distillates and will develop 16 HP. per hour with less than 1 pt. of these fuels. The unit is designed for use where electric current is not available or is of excessive price, and the engine can be removed and an electric motor substituted whenever changed conditions make it desirable. The engine is adaptable to any of the deep well pumps made by the Hill-Tripp Pump Co., Anderson, Ind.

IRRIGATION PROJECTS IN OREGON—OUTLINE OF SEVERAL DEVELOPMENTS NOW UNDER CONSIDERATION.

A large amount of construction work is proposed for various irrigation projects in the state of Oregon. In the central part of the state in particular many developments are under consideration. The state and the United States have been co-operating in the preparation of plans and cost estimates for the construction of a number of large projects. The object of this work is to have at hand preliminary information that will not only permit of the use of water but that also will tend to induce the carrying out of the developments by districts or private parties. In a paper presented before the Oregon Irrigation Congress Mr. John H. Lewis outlined some of the projects so far considered. The following details were taken from his paper. It should be noted here that the people of three communities already are making use of the information collected by the state and have taken active steps for the formation of the separate irrigation districts. These districts come under the Deschutes Project, the Ochoco Project and the Silver Lake Project:

Deschutes Project.—This project proposes the irrigation of 200,000 acres in Crook and Jefferson Counties with water stored on the Upper Deschutes River. Two reservoir sites have been suggested. The principal one is on the main stream 16 miles south of the town of Bend and just above Benham Falls. A rock fill and south dam with its spillway crest 54½ ft. above present water surface will store 440,000-acre feet and back the water up stream for a distance of 18 miles, flooding 19,000 acres. A similar dam at Crane Prairie, 30 ft. in height, will store 110,000 acre feet.

The project is divided in four units. The North unit includes 100,000 acres of land in the vicinity of Madras and Culver. The cost of this development is estimated at $55.58 per acre, which includes concrete-lined canals and permanent structures practically throughout. The West unit consists of about 20,000 acres lying between Cline Falls and Sisters. This will cost $35 to $43.50 per acre depending on the scheme of construction adopted. The East side unit includes 35,000 acres in the vicinity of Redmond, or what is known as the north canal lands of the existing Carey act projects. The estimated cost ranges from $32 to $42.50 per acre, depending on various assumptions as to the value of existing work. The South unit overlaps the old Benham Falls-Carey Act segregation, south of Prineville. It includes 48,000 acres of irrigable land which can be reclaimed at a cost of $60.50 per acre.

Ochoco Project.—This project covers 15,500 acres on the north side of Crowhead River near Prineville. Water will be provided through the construction of an earth fill dam on Ochoco Creek 6 miles above Prineville. With its spillway crest 113 ft. above present water surface, 40,000 acre feet could be stored. The estimated cost is $51.50 per acre. All structures are planned to be of concrete and the main canal is to be lined with concrete.

Investigation also was made of the irrigation possibilities on Crooked River. Relatively cheap storage could be had at Post on the headwaters of the stream, but to irrigate a land near Prineville from this source would be more expensive than from Ochoco Creek. A dam at Post with spillway crest 131 ft. above present low water in Crooked River would store 260,000 acre feet at a cost of $3.40 per acre foot of capacity. By a long canal diverting water from Crooked River about 12 miles above Prineville and extending through the irrigable lands of the Ochoco project to the north unit of the Deschutes project, a distance of approximately 50 miles, it would be possible to serve about 46,000 acres of this 100,000 acres in the North unit and about 9,000 acres in the Ochoco project at a cost of $76 per acre.

Silver Lake Project.—This comprises 68,000 acres in Northern Lake County. It is estimated the land can be irrigated at a cost of approximately $28 per acre. The land is located around the edge of Paulina Marsh in the vicinity of the town of Silver Lake and extends northward along the edge of the desert to Fort Rock and Fremont. The project could be constructed in three separate units as conditions warrant with but little increase in cost. Water will be provided in part from Silver, Bridge and Buck Creeks, which flow in Paulina March, and partly by diversion from Kalmath River drainage basin. The streams flowing into Sycan Marsh could be carried across a low divide by constructing two short tunnels to supplant the flow of Silver Creek. About 60,000 acre feet of the water would be stored through the construction of a dam at the lower end of Thompson Valley, located near the head of Silver Creek. Several other small reservoir sites are available near the land. Power could be developed from Silver Creek at a point just below the proposed Thompson Valley reservoir. This power might be transmitted to the desert north and east of Silver Lake for use in pumping underground waters of this region for irrigation. Another suggested use for this power is pumping Ana River water to lands at the north end of Summer Lake.

John Day Projects.—The project provides for the irrigation of 122,000 acres of land along the Columbia River between Arlington and Umatilla. The plan calls for the diversion of water from John Day River through a 75-mile supply canal of 665 second feet capacity. Four miles of the canal would be taken up by tunnels through ridges and for an equal distance would be carried across deep canyons in inverted steel siphons. The estimated cost of construction is $125 per acre. Storage would be necessary. A 140-ft. masonry arch dam at Rayville on the Upper John Day River would improve 112,000 acre feet of water and two earth fill dams 70 ft. and 85 ft., respectively, would store 133,000 acre feet in the Carty reservoir site at the upper edge of the tract to be irrigated. By this arrangement of reservoirs the supply canal could be kept full and utilized practically the entire time. This is a very important feature of the design as the cost of the canal is 39 per cent of the total cost of the project. The total estimated cost is $15,240,000. This estimate is based upon steel and concrete construction throughout for the delivery of 3 acre feet per season, with lateral canal capacities sufficient to deliver heads of 10 second feet to each 40 acre tract. An alternative scheme to irrigate 225,000 acres at a cost of $31,000,000 also has been outlined. Because of the great cost and the fact that the project could not be built in small units, detailed plans were not worked out. However, the total cost is so great in both cases that there is little likelihood of financing either project in the immediate future unless through public funds with long time payments and very low interest.

Malheur Project.—This project lies between Ontario and the mouth of the Malheur Canyon, 14 miles above Vale. Nine ditches already divert water from the regular flow of the Malheur River for the partial irrigation of approximately 13,000 acres. Much additional land under these canals is not irrigated at the present time for lack of water. The stream goes dry in the summer time when water is most needed. By enlarging and extending these canals 31,600 acres can be irrigated by gravity flow, at a cost of $20 to $40 per acre. The 13,000 acres having a partial water right could be provided with a full water right at from $1 to $10 per acre.

By constructing a dam with a spillway crest 85 ft. above low water at the Warm Springs reservoir site on the middle for of Malheur River, 3 miles above its juncture with the main stream, it would be possible to store 159,000 acre feet. This with the regular flow of the stream would deliver 2.6 acre feet of water to 39,000 acres. The cost for stored water would be approximately $4 per acre foot at diversion. In addition to the 31,600 acres, 4,800 acres in lower Willow and Sulky Creek Valleys could be served by a gravity canal diverting water for Malheur River about one mile above the mouth of the canyon at a cost of $62 per acre. Also 2,000 acres lying immediately above the canal could be served by direct connected pumps at $68 per acre. Another resrevoir site is proposed near

Beulah. By utilizing this and diverting water above the Harper Ranch, 20,000 acres in addition could be served at $125 per acre.

Owyhee Project.—The land in this project lies on the upper Owyhee Beach near Ontario. Water from the Beulah reservoir site, mentioned above, could be delivered to 25,000 acres at a cost of $125 per acre. The canal for this purpose would divert on the south branch of the stream and carry the water through a pass in the hills east of Vale. The lower portion of the lands in the Owyhee project can be irrigated from Owyhee River. On a basis of 20,000 acres the cost would be $65 per acre. Water would be stored in the Duncan Reservoir site and diverted from the river by a 60-ft. dam a short distance above the present Owyhee canal diversion.

SPRINKLER TRUCK OPERATIONS AT PORTLAND, OREGON.

(Contributed.)

Street Flushing and Sprinkling Truck of City of Portland.

The illustration shows a street flushing and sprinkling truck used in Portland, Ore. The truck is a regular 5-ton Riker equipped with tank, capacity of which is between 1,200 and 1,300 gal. The water is forced onto the street under 50 lb. pressure. A centrifugal pump is used, operating from the engine. The tire equipment is 40x6 Goodrich Demountable all around. This truck cost the city $5,500, complete, and operates with a crew of three men at a cost of $0.1384 per 1,000 sq. yd. It leaves very little refuse for carts to pick up the largest portion of this going into the sewers. By this process the streets stay clean longer, as no sediment is left to turn to dust as in the case with sweepers. The sweeping outfits represent an outlay of $5,620 as follows:

3 sweepers	$1,200
1 sprinkler	400
Carts	500
12 horses at $250 each	3,000
8 sets of harness at $50 each	400
4 sets of harness at $30 each	120
	$5,620

The sweeper required a crew of 12 men and the average cost per 1,000 sq. yd. was 31 ct.

Portland has 370 miles of paved streets, with 20,800 square yards to the mile. One of the trucks will cover 6 miles a day at a cost of $17.27. The sweepers covered the same ground in an equal time at a cost of $38.69. Thus the truck is saving the city $21.42 in a working day of eight hours. Allowing two eight-hour shifts with an average of 300 days to the year, it will be seen that a saving of $6,426.00 is effected, or enough to pay for the truck. These operating costs do not include depreciation.

COST DETERMINATIONS OF 22-IN. STEEL PIPE MANUFACTURE.

Contributed by H. A. Whitney, San Francisco, Cal.

Three determinations of cost of manufacture of this 22-in. pipe were made during its construction at W. W. Montague & Co.'s Works, San Francisco, Cal.; one at the old works at 6th and Townsend while working on 11/64-in. steel, another at the old works while on 3 16-in. steel, and the third after the fire of Apr. 18, 1906, after work on the 3 16-in. steel was resumed at the new works at 17th and Kentucky Sts.

Possibly many factors should be considered in accounting for the divergence of the three results, but the principal reason for their difference is that two different methods were followed. In the first two determinations, the number of pieces turned out per hour of actual running time by each man or machine was observed. When reduced to days, this would give too high an output, and evidently either not enough allowance was made for breakdowns and other lost time, or else the men did not exert themselves as much after the fire as before—probably both. In the third determination the total actual cost of labor for a certain period, plus the proper allowance for power, dip, fuel, handling, rivets, etc., divided by the total weight of pipe produced by that money, gave a higher and probably more reliable result for the cost of production. It will be noticed that in the various determinations, the number of men assigned to the several machines is different, and also that the wages paid at different times varies considerable.

First Determination, September, 1905.

Cost of Manufacture of 22-in. Riveted Steel Pipe, 11/64 in. Thick, in 29-ft. 2-in. Lengths of Six Sheets Each. Loaded Complete on Cars Alongside Works of W. W. Montague & Co., at 6th and Townsend Sts., San Francisco.

Unloading Sheets and Loading Pipe:

One foreman and four men unload 500 sheets with crane in one day—9 hours.

Same gang load and bind a carload of 16 lengths with crane in ½ day.

Power—2 HP., per day	$0.72
Unloading (power, $0.00141; labor, $0.01496), per sheet	0.0164
Loading (power, $0.0225; labor, $0.2344), per pipe	0.2569
Total labor and power, unloading and loading, per pipe	0.3555
Total labor and power, unloading and loading, per foot	0.0121

Punching:

One man @ $3.25 and one man @ $2 punch 19 sheets for the seams and 25 sheets for round seams per hour—one pass.

Power—5 HP., per day	$1.80
Power—5 HP., per pipe	0.111
Labor, per pipe	0.324
Total cost of punching, per pipe	0.435
Total cost of punching, per foot	0.0149

Beveling and Scarfing:

One man @ $3 and two men @ $2 bevel and scarf 10 sheets per hour.

Power—1 HP., per day	$0.38
Power, per pipe	0.0120
Labor, per pipe	0.4667
Total cost of beveling and scarfing, per pipe	0.4787
Total cost of beveling and scarfing, per foot	0.0164

Rolling	
One man @ $3 and two men @ $2 roll 30 sheets per hour.	
Power—1 HP., per day	$0.36
Power, per pipe	0.00799
Labor, per pipe	0.1555
Total cost of rolling, per pipe	0.1635
Total cost of rolling, per foot	0.0056
Tacking:	
One man @ $3.25 lays lap, puts in one countersunk rivet in each end and one flat head rivet in the large end, turns in small end, and delivers to riveting machine, 5 rolled sections per hour.	
Labor, per pipe	$0.4332
Labor, per foot	0.0148
Straight Seaming on Whiting No. 6 Can Riveting Machine:	
One man @ $3.25 and one man @ $2.50 rivet 10 sections, each section with 73 ⅜-in. x ⅞-in. R. H. rivets, cold, per hour.	
Power—1 HP., per day	$0.36
Power, per pipe	0.024
Labor, per pipe	0.3833
Total cost of straight seaming, per pipe	0.4073
Total cost of straight seaming, per foot	0.0139
Total cost of straight seaming, per rivet	0.000893
Rounding Up, Etc.:	
One man @ $3.25 lays lap, rounds up sections after riveting, and acts as helper, caring for the sections as fast as turned out by the riveting machine.	
Labor, per pipe	$0.2167
Labor, per foot	0.0074
Round Seaming:	
One round seamer @ $3.78 and helper @ $2 run 11 round seams in 9 hours, 54 F. H. rivets per seam, punching of slip end done by hand.	
Labor, per pipe	$2.6273
Labor, per foot	0.09
Labor (cost per rivet)	0.00973
Caulking:	
Two men @ $3.25 each, with pneumatic hammers, fuller and caulk 8 pipes in 9 hours.	
Power—9 HP., per day	$3.24
Power, per pipe	0.405
Labor, per pipe	0.8125
Total cost of caulking, per pipe	1.2175
Total cost of caulking, per foot	0.0417
Coating:	
Four men @ $2.50 each dip about 20 pipes per day. Fuel, dip, power, water, etc., estimated by Montague & Co. at $10 per day.	
Labor, per pipe	$ 0.50
Other costs, per pipe	0.50
Total cost of dipping (estimated), per pipe	1.00
Total cost of dipping (estimated), per foot	0.0342
Rivets:	
31 lb. of rivets @ 4½c per lb., per pipe	1.395
Steel:	
1,357.02 lb. of steel @ $0.0242, per pipe	32.8399
Foreman:	
Half of his time @ $4 per day, per pipe	0.25
Total cost of manufacture, excluding steel, per pipe	8.9797
Total cost of manufacture, including steel, per pipe	41.8196
Total cost of manufacture, excluding steel, per foot	0.30741
Total cost of manufacture, including steel, per foot	1.43168
Average weight of 128 pipes, lb.	1,455
Cost of steel per lb. of completed pipe	$ 0.02257
Totol cost of manufacture, excluding steel, per lb.	0.00617
Totol cost of manufacture, including steel, per lb.	0.02874

In the above no allowance is made for repairs, testing, insurance, taxes, interest, or bookkeeper's time. This result is probably low, for the reason already given.

Second Determination, December, 1905.

Cost of Manufacture of 22-in. Riveted Steel Pipe 3/16 in. Thick, in 29-ft. 2-in. Lengths of Six Sheets Each, Complete, on Cars Alongside Works of W. W. Montague & Co. at 6th and Townsend Sts., San Francisco.

Unloading Sheets and Loading Pipe:	
Total cost (same as before), per pipe	$0.3555
Punching:	
One man @ $3 and one man @ $2.50 punch 12 sheets for the straight seams per hour and 25 sheets for the round seams per hour, making two passes through punch for the straight seams instead of one as before.	
Power—5 HP., per day	$1.80
Power, per pipe	0.1480
Labor, per pipe	0.4522
Total cost of punching, per pipe	0.6002
Total cost of punching, per foot	0.0205
Beveling:	
One man @ $2.50 and one man @ $2 bevel 24 sheets per hour.	
Power—1 HP., per day	$0.36
Power, per pipe	0.0100
Labor, per pipe	0.1250
Total cost of beveling, per pipe	0.1350
Scarfing:	
Two men @ $2 each, scarf 24 sheets per hour.	
Labor, per pipe	$0.111
Rolling:	
One man @ $3 and two men @ $2 roll 300 sheets in 9 hours.	
Power—1 HP., per day	0.36
Power, per pipe	0.0072
Labor, per pipe	0.1400
Total cost of rolling, per pipe	0.1472
Tacking:	
Same as before, per pipe	$0.4332
Straight Seaming:	
One man @ $3.25 and helper @ $2 rivet 90 sections per day of 9 hours. Time required per section, without delays, 5 minutes.	
Power, as before, per pipe	$ 0.0240
Labor, per pipe	0.3500
Total cost of straight seaming, per pipe	0.3740
Rounding Up, Etc.:	
Same as before, per pipe	0.2167
Round Seaming:	
Same as before, per pipe	2.6273
Caulking:	
Same as before, per pipe	1.2175
Coating:	
Same as before, per pipe	1.0000
Rivets:	
Same as before, per pipe	1.3950
Steel:	
1,499.88 lb. @ $0.0242, per pipe	36.2971
Foreman:	
Same as before, per pipe	0.2500
Total cost of manufacture, excluding steel, per pipe	8.8627
Total cost of manufacture, including steel, per pipe	45.1598
Total cost of manufacture, excluding steel, per foot	0.30341
Total cost of manufacture, including steel, per foot	1.54604
Cost of steel per lb. of completed pipe	0.02327
Average weight of pipe, lb.	1,563.6
Total cost of manufacture, excluding steel, per lb.	$ 0.005668
Total cost of manufacture, including steel, per lb.	0.028882

In the above no allowance is made for repairs to machinery, testing pipe, insurance, interest, taxes, or bookkeepers' time. This result is probably too low, as already stated.

Third Determination, May 11, 1907.

Cost of Manufacture of 22-in. Riveted Steel Pipe, 3/16 in. Thick, in 29-ft. 2-in. Lengths, Loaded Complete on Cars Alongside Works of W. W. Montague & Co. at 17th and Kentucky Sts., San Francisco.

This is the actual cost for labor on this pipe from February 5, 1907, to May 11, 1907, compared with the actual weight of pipe turned out by that amount of labor.

Cost of labor to date, including foreman's time	$2,546.00
Total weight of pipe completed for the above amount, lbs.	364,032
Average weight per completed pipe (642 pipes) at new shop, lb.	1,559.95
Average weight per completed pipe (1,014 pipes) at old shop, lb.	1,563.6
Average length per completed pipe at new shop, ft.	29.23
Average length per completed pipe at old shop, ft.	29.21
Average weight per foot of completed pipe at new shop, lb.	53.38
Average weight per foot of completed pipe at old shop, lb.	53.52
Weight per foot of uniform cylinder, 3/16 in. thick, 22 in. diam., lb.	40.26
Details of manufacture have added, at old shop, per cent	32.93
Details of manufacture have added, at new shop, per cent	32.58

Note.—Pipe made by Francis Smith & Co. (900 ft.) had a slightly less per cent of details, because of wider spacing of rivets and less weight of coating applied.

Weight of rivets (170 round seam and 456 straight seam) per pipe, lb.	30.63
Weight of rivets per foot, lb.	1.048
Weight added by rivet heads, per pipe, lb.	18.34
Weight added by rivet heads, per foot, lb.	0.627
Weight added by rivet heads, as per cent of weight complete, per cent	1.17
Weight of rivets for 364,032 lb. of completed pipe, lb.	7,388
Weight of steel for 364,032 lb. of completed pipe, lb.	354,000
Weight of steel required per foot of laying length, lb.	51.53
Price of steel to Montague & Co. laid down in San Francisco, per lb.	$ 0.0242
Price of rivets, ⅜ in. x ⅞ in., laid down in S. F., per lb.	0.045
Price of dip, since consolidation of producers (about 1/1/07), per ton	20.00
Price of dip, before consolidation of producers (about 1/1/07), per ton	12.00
Price of fuel oil, 19° gravity, for dip kettle, bbl.	1.00
Price of electric power, kw. hr.	0.04
Cost of labor per lb. of completed pipe	0.0069939
Cost of rivets per lb. of completed pipe	0.00088
Cost of dip per lb. of completed pipe	0.0004006
Cost of power per lb. of completed pipe	0.000256
Cost of fuel oil per lb. of completed pipe	0.0000475
Cost of steel per lb. of completed pipe	0.023268
Total cost of manufacture, per lb. of completed pipe, f. o. b. San Francisco	0.008578
Total cost of manufacture, per lb. of completed pipe, including steel	0.031846
Total cost of manufacture, per ft. of completed pipe, including steel	1.699939
Cost of sand-blasting, per lb. of completed pipe	0.00096
Cost of sand-blasting, per ft. of completed pipe	0.05132
Cost of rivets per ft. of completed pipe	0.0472
Cost of manufacture per ft. without sand-blasting	0.4579
Cost of manufacture per ft. with sand-blasting	0.509
Cost of steel, per foot of completed pipe	1.247

The foregoing results are derived from the following distribution of men, turning out 8 completed pipes, 30 ft. long, per day:

Unloading steel and loading pipe, 4 men @ 28c per hour.
Punching, 1 man @ 40c and 1 man @ 28c per hour.
Beveling, 2 men @ 28c per hour.
Scarifying and rolling, 2 men @ 28c per hour.
Tacking, 2 men @ 36c per hour.
Straight seaming, by machine, 1 man @ 33⅓c and 1 man @ 28c per hour.
Rounding up, laying lap, etc., 2 men @ 36c per hour.
Round seaming, 4 men @ 42c and 4 helpers @ 28c per hour.
Caulking, 2 men @ 36c per hour.
Dipping, 1 man @ 33⅓c, 2 men @ 28c per hour.
Foreman @ 45c per hour.

These figures are quite dependable, as they are the result of actual practice on this job, and represent the best procedure in San Francisco at present. The results of cost determinations may be compared as follows:

Old shop, 11/64-in. pipe, cost per pound, complete	0.02874
Old shop, 3/16-in. pipe, cost per pound, complete	0.02888
New shop, 3/16-in. pipe, cost per pound, complete	0.03185
Old shop, 11/64-in. pipe, cost per pound, excluding steel	0.006170
Old shop, 3/16-in. pipe, cost per pound, excluding steel	0.005668
New shop, 3/16-in. pipe, cost per pound, excluding steel	0.008578

Notes.

TABLE I.—RESULTS OF TEST ON SHEETS 60-IN. X 73¼-IN. X 11/64-IN.

Draft No.	Wt. blk.	Wt. pnch.*	Loss in pnch.	Wt. bev.	Loss in bev.	Weight made up.	Wt. dipped.	Wt. of dip added.
A-6 sheets.	1,388	1,377	11	1,362	15	1,391	1,452	61
B-6 sheets.	1,375(?)	1,347(?)	28(?)	1,331	16	1,362½	1,418	55½
C-6 sheets.	1,433	1,421	12	1,405½	15½	1,439	1,510	71
A-1 sheets.	232	230	2	227½	2½	.....	.....	....
B-1 sheets.	231	229	2	226½	2½	.....	.....	....
C-1 sheets.	233	231	2	228½	2½	.....	.....	....

*As the slip end of each section is not punched by machine, but by hand by the round seamers when making up the pipe, the "weight made up" minus the "weight beveled" does not give the number of pounds of rivets used.

In set B either the first weighing or the second, or both, was in error in some way. The inconsistency was noticed and its cause sought, but it could not be checked up.

Average weight of (large number) sheets, 60 in. x 73¼ in. x 11/64 in., Carnegie, lb.	226.17
Theoretical weight of sheets, lb.	214.08
Per cent overweight	5.65
Average weight of 2,306 sheets, 60 in. x 73¼ in. x 3/16, Carnegie, lb.	249.98
Theoretical weight of sheets, lb.	233.54
Per cent overweight	7.04
Average weight of 775 sheets, 60 in. x 73¼ in. x 3/16 in., Lukins, lb.	251.87
Theoretical weight of sheets, lb.	233.54
Per cent overweight	7.89

Weight of rivets, actual tests:
23 ⅜ in. x ⅞ in. round head weigh 1 lb.
25 ⅜ in. x ⅞ in. flat head weigh 1 lb.

Dip kettles are heated by two oil burners each, of the Golden Gate type, using compressed air instead of steam. Both the air pressure and the oil pressure are maintained at 30 lb. per sq. in. Each burner consumes 1 bbl. fuel oil per day of 9 hours.

The shop is driven by three induction motors of 20, 15 and 10 HP. capacity. Power costs 4 ct. per kw. hr., or about 4 ct. per actual HP. hour.

METHOD EMPLOYED IN LAYING A 16-IN. CAST IRON PIPE ACROSS A RIVER AT BINGHAMTON, N. Y.

Contributed by Frank C. Perkins, Buffalo, N. Y.

Figures 1 and 2 show the method employed by the engineering department of the Binghamton, N. Y., city water works in completing a river crossing of 16-in. pipe which formed the connecting link between the south and west sections of the city in the new Intermediate Service System, now being installed in Binghamton. For this data the writer in indebted to H. B. Hemstrought of the Board of Water Commissioners.

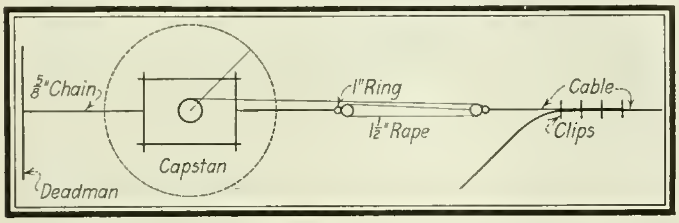


Fig. 1.—Diagram Arrangement of Pipe Laying Plant.

It is of interest to note that the line was laid under the Susquehanna River at its junction with the Chenango River. Sections and soundings were taken in the early summer along the proposed line of pipe, and several different methods for making the crossing were worked out and discussed, before the method used was decided upon. It was first thought that it would be most practicable to connect enough pipe together to cross the deepest part of the river, float it out and lower it into place so that both ends could be picked up in the shallow water and the pipe laid both ways to either bank.

It is held that in an ordinary season this method would probably have been the most feasible of all, as at the time of taking the sections the river was at mean low water. The above method, however, was rendered impossible, due to the fact that a week after the sections were taken the river rose 3 ft., and, although sometimes rising higher, never fell below the 2½-ft. mark. Taking into consideration the high water and the velocity of the current, which was, at the time of laying the pipe, 9.6 ft. per second, it was decided that the pipe could be pulled more economically than by any other method.

There was a capstan designed, using heavy timbers and having a 11'lever arm, a special cap was cast for the end of the pipe, and a cradle was built to carry the pipe down the north bank of the river. The capstan was built and set up on the south side of the river and the cradle laid in place on the north side. A sash cord was pulled across with a row-boat from the north bank to the south side of the river and a 1-in. rope was attached to the sash cord and pulled across by hand. The 1-in. rope was then put on the capstan and the ⅞-in. steel haulage cable, used for pulling the line was drawn over.

It may be stated that three lengths of Ward's joint pipe were made up on the foot of the cradle and the cap caulked onto the head end of the line. The pull was started with a 1-in. rope directly around the capstan and attached to the cable. After four lengths had been pulled into the river, the 1-in. rope broke, the direct pull was abandoned and a special tackle arranged. Pulling was then continued steadily for five days, at the end of which time 35 lengths of pipe were in the river. Thirteen pipe were the maximum number pulled in during any one day. The pull was practically continuous, as while the tackle was being changed on the south side, another length of pipe was being made into the line on the north bank.

It is of interest to note that on starting to pull on the morning of the sixth day, the ⅝-in. chain holding the blocks snapped; after repairing the chain the pull was again attempted and the 1-in. ring on the block broke. The ring was repaired and the pull barely started when the bridle on the pipe line pulled apart. Pulling was then abandoned and the end of the pipe-line raised with a tripod in 4 ft. of water.

It may be stated that the cap was then removed from the end of the pipe and preparation was made for laying the pipe by having four horses, built of heavy timber. They were placed two on each side of the line of pipe and on these horses 4x8-in. stringers 14 ft. long were laid to insure rigidity. A new length of pipe was then brought out on a scow of 3 tons' displacement, rolled onto the framing, and swung into place with a second tripod, as shown in the photograph. This new length was then caulked into the line and a rope sling swung from the stringers under the line between the two tripods, as an added factor of safety, while lowering the line. The line was next lowered until the end of the last pipe was about 1 ft. above the water, the rear tripod brought ahead and the operation repeated until the shore was reached.

There were seventeen lengths of pipe laid in this manner in six days, making a total of 52 lengths of pipe in 12 days. During the pull the capstan, operated by one horse, was found to develop power far in excess of that necessary, and the only difficulty encountered up to the time the chains broke, was the continual slipping of the clips connecting the blocks to the main cable. At first the light type of wire clip was used for this purpose, but these slipped and broke. Eccentric grips and heavy wire grips were also tried, but the best results were finally obtained with a series of extra heavy wire clips. It is interesting to note that $306.27 was the total cost of laying the line, exclusive of materials.

ALTERNATE TYPE SPECIFICATIONS FOR BITUMINOUS MATERIALS.*

By Arthur H. Blanchard, Professor in Charge of Graduate Course in Highway Engineering, Columbia University.

There recently has been considerable discussion pertaining to the advisability of the adoption of so-called "alternate type" specifications in preference to the so-called "blanket" specifications for bituminous materials. By alternate type specifications is meant a series of specifications, each of which covers the physical and chemical properties of the most desirable grade of a given type of bituminous cement for the purposes for which it is to be used. On the other hand, a blanket specification covers in one set of requirements, pertaining to physical and chemical properties, all the types of bituminous cement which are to be used in connection with the construction of a given kind of pavement. For example, in the case of specifications for asphalt cement for bituminous concrete pavements, it would be desirable under alternate type specifications to have not less than five sets of physi-

Fig. 2.—View of Pipe Laying Plant in Operation.

---

*From a paper, "Recent Developments in Bituminous Macadam and Bituminous Concrete Pavements," presented at Third Canadian Convention and International Good Roads Congress.

cal and chemical requirements, the limits for each requirement being as narrow as the several processes of manufacture would permit, while on the other hand a blanket specification would cover with a wider range of limits the same chemical and physical properties for the five types mentioned. As an illustration will be cited the limits in the cases of Specifications "A" to "E", inclusive, under the alternate type specification method for specific gravity, and the penetration at 25° C. (77° F.):

	"A"	"B"	"C"	"D"	"E"
Sp. Gr.	0.97-1.00	1.00-1.03	1.03-1.04	1.025-1.05	1.04-1.06
Pent.	75-90	90-100	70-90	85-95	140-160

In the case of a blanket specification to cover the same grades of the several types, the limits for specific gravity would have to be 0.97 to 1.06 and the limits for penetration would be 70 to 160. The penetration test, for example, can only be of maximum value when applied to the grade of a specific type of bituminous cement which is most suitable for the type of pavement in question. In the case of the bituminous concrete pavement of the type mentioned, the proper penetration limits for a California asphalt lie between 70 and 90, while for a fluxed Bermudez asphalt, to be used in exactly the same type of pavement and under the same conditions, the penetration limits should be between 140 and 160. It is evident that to attempt to cover the penetration limits for both materials in one specification is impracticable. In the first place, such limits as 70 to 160 are so wide as to insure but little uniformity in different lots of the same material, and in the second place an entirely unsuitable material of one class could be supplied under the maximum or minimum test limits of the other class.

The proper use of alternate type specifications allows the contractor to bid to supply so many tons of bitumen which will comply with any one of the sets of requirements. It will be noted, therefore, that the contractor is in exactly the same position as in the case when he bids to supply any asphalt cement which will comply with the requirements of a blanket specification.

A RECENT WATER WORKS PUBLICITY CAMPAIGN AT TERRE HAUTE, IND.

Contributed by Dow R. Gwinn, President and Manager, the Terre Haute Water Works Co.

In most of our larger cities it is not necessary to have a water works publicity campaign, for the purpose of getting customers, for practically every house that is fit to live in has water connections. However, in cities like Terre Haute, under-laid with about 100 ft. of sand and gravel, with the Wabash River along its western border, the conditions are different.

It is an easy matter to get a supply of clear, cold water from the ground in almost any part of the city of Terre Haute by driving a pipe into the ground. In some places the water is only 15 ft. below the surface. Many people have become accustomed to the back yard pump and look upon city water as a luxury; notwithstanding that the rate of pure filtered water for domestic use in a six-room house is $5 a year, payable quarterly. In 1900, after the plant had been in operation 27 years, there were only 2,200 water consumers.

The company has done a lot of advertising in the newspapers, with circular letters and also lead pencils. At the present time (November, 1915), there are about 6,800 water consumers. There are a large number of good houses along the water mains (a total of nearly 100 miles) that should have city water.

Personal Solicitation.—In order to reach the occupants of these houses a solicitor began work in May, 1915. We were very fortunate in securing as a solicitor a retired physician of unusually fine character and genial disposition, coupled with an extensive personal acquaintance in the city. He made a point of making a friendly visit with those who were not yet included, as we say, "In the Happy Family of Filtered Water Users." He set forth the advantage of a bathroom and water in the kitchen in glowing terms and pointed out the personal loss of those who were not supplied with city water. In some cases he dwelt upon the danger of contamination of water taken from wells in a populous district. He explained the scientific method of purification of city water which is tested every day in the laboratory of the company and occasionally examined by the State Board of Health.

One of the principal objects of the campaign was to secure the names of those who might become customers of the company. Where the house was rented the name and address of the owner was secured. Where the tenant was particularly interested in the proposition and appeared willing to pay more if a bath room was installed the owner of the property was looked up and asked to make water connections for his tenant. Each real estate agent was called upon several times and an effort made to show the advantages of having city water in rented property; that there was a growing demand in the city for small modern houses and it was pointed out that there were a number of houses without city water unoccupied at this time; that the empty house earns no money; that a better grade of tenants could be secured for modern houses and that the additional investment brought a good rate of interest. We secured from several of the real estate men lists of property (and the address of the owners that they were agents for) that were not yet provided with city water.

As a result of this campaign we made up a mailing list of the property owners and tenants to whom printed matter was sent from time to time. The general list consisted of about 1,200 names. From the general list there was made a condensed list of what was considered to be the best prospects, with statement following each name as to when water connections would probably be made. This list consisted of about 350 names and is known as our Prospect List, to distinguish it from the general list. Many of the names on the Prospect List were furnished to each of the plumbers doing business in the city and the rest of the names were available to them. We were somewhat disappointed, however, in the lack of interest displayed by the plumbers.

First Circular Letter.—First, we secured a good letter from a contracting firm, setting forth their experience in remodeling old houses, and this was mailed with a letter from the water company. The two letters follow:

(Text of First Circular Letter from Water Company.)

To the Property Owner:

Increased rate of interest on investment—better tenants.

That sounds good—but the query is, "How is it to be done?"

Some time ago, Mr. C. A. Kemper was telling the writer about several houses that he had remodeled and how the owner had materially increased the return on the investment, had secured a better grade of tenants and kept his property occupied. In addition to other improvements, city filtered water was put in the bath room and kitchen. We asked Mr. Kemper to give us the particulars and enclose copy of his letter; it is a strong argument for a good grade of houses. It shows that modern houses of medium size are readily rented; that they bring a good return on the investment; that a good house draws a better class of tenants than a poor house.

An inspection of the new houses being erected at this time will show that a large percentage of them are being provided with city filtered water in the kitchen, while many have bath rooms.

"This is a condition and not a theory," as Grover Cleveland said.

The observing and far-seeing, successful business man is quick to see what the people want and then makes preparation to furnish what is desired. By acting promptly, he reaps a profit.

There is a demand, a growing demand, for modern, medium sized houses in Terre Haute. There is no doubt about it. Some of the contractors have recognized this demand and are putting up houses to meet it. As soon as these houses are finished, they are promptly rented. Good tenants are moving from the houses without modern conveniences to the houses with bath rooms.

Is it the part of wisdom to wait until the old house is empty, until the good tenant has rented one of those new modern houses?

Some tenants just take it for granted that the landlord will not put in a bath room or even provide city water at the kitchen sink—and, occasionally, the landlord finds he has an empty house on his hands.

Why not recognize the demand for better houses and fix up the old house? Why not do it now?

Yours very truly,
THE TERRE HAUTE WATER WORKS CO.

(Text of contractor's letter, enclosed with foregoing circular letter.)

Terre Haute Water Works Co., City.

Gentlemen: We are pleased to hand you herewith our reasons for advocating modern houses as rental and income investments. The examples given herewith show the advantage of making houses modern.

Three Five-Room Houses Built in 1913.

Average additional investment for city water in bath room, kitchen and laundry, for furnace and concrete basements, $500.

Average annual rent for these houses	$280
Average annual rent for 5-room houses without modern convenience, in same square	162
Increase rent	$118

$118 is 23.6 per cent interest on $500. In two years, the owner has not lost over ten days' rent on all three houses.

Seven-Room House Remodeled in 1914.

Formerly rented to two families, poor class of tenants and poor pay. This house was in bad repair. It was moved to another lot, a concrete basement and furnace provided; the roof was refinished; the interior remodeled for 6 rooms; city water put in bath room, kitchen and laundry. Total cost of all the improvements was about $1,200.

Present annual rent	$300
Former rent received	150
Gain	$150

$150 is 12½ per cent on $1,200. Outside of the return on the cost of improvement, is the satisfaction to the owner of having a good, prompt-paying tenant.

Five-Room Cottage Remodeled in 1914.

With new concrete basement but without bath room fixtures and furnace, rented for $17. The total cost of putting city water in the bath room, kitchen and laundry and installing a furnace was $300.

Present rent at $23 per month per annum	$276
Former rent at $17 per month per annum	204
Gain per annum	$ 72

$72 is 24 per cent on $300.

Yours very truly,
KEMPER & CO.,
Per C. A. Kemper.

Second Circular Letter.—A little later on we sent the letter from Mr. Bunger (real estate and loan agent), with our second circular letter. The two letters follow:

(Text of second circular letter from water company.)

To the Property Owners:

"EXPERIENCE IS A GOOD TEACHER."

Some of us want to have our own personal experience, but here is a chance to learn by the other fellow's experience. The late Mr. Bunger was an enterprising, far-seeing, and successful contractor and real estate man. He built 25 or 30 houses of a modern type, which were in demand as soon as completed. Shortly before the automobile accident, which caused his death, Mr. Bunger was operating in Indianapolis, and knowing something of his success here, the writer requested him to give us a statement of his experience.

We are enclosing copy of Mr. Bunger's letter. It contains first hand information from one who had actual experience and who gives reasons for building houses with bath rooms. When operating in Terre Haute, he wanted to know, before buying a lot, that there was a water main in front of it. He was one of those who recognized the growing demand in Terre Haute for houses with bath rooms.

The demand is here. The question is, how can it be met? It is being met, to a certain extent, by the building of modern houses. That is one way. There is another way which should appeal to those who have fairly good houses; that is, put in bath rooms with city filtered water.

Our solicitor reports a case where a gentleman is paying $16 per month for a small house, who said he would pay $22 if the owner would put in a bath room with city water.

At this time, there are a number of empty houses and yet a "For Rent" advertisement of a modern 5-room cottage brought thirty-nine inquiries. Just think of it! Does this not show that there is a demand for small, modern houses?

We will be glad to give information, and if you wish, will see that you have estimates on cost of plumbing.

THE EMPTY HOUSE EARNS NO MONEY.

Yours very truly,
THE TERRE HAUTE WATER WORKS CO.

(Text of Mr. Bunger's letter, enclosed with second circular letter.)

Terre Haute Water Works Co., Terre Haute, Ind.

Dear Sir: In answer to your inquiry as to my experience in the construction and handling of real estate in your city as an investment as well as for the purpose of reselling, will say, that I feel that I owe my success in this line to that of taking advantage of the modern conveniences your city affords.

My first experience in this line was far from a success, due to the fact that my investments were in buying and constructing properties not modern in any way. These properties I soon learned only appealed to the poorer class of tenants. A class of tenants who were not able to buy homes, and due to their financial conditions made the rent collections uncertain.

I found that properties of this class were a poor investment and immediately changed my plan of operation. I began buying lots on improved streets where modern conveniences could be had, and building modern homes. Also adding bath rooms and kitchen sinks to houses already constructed. The change proved to be a very beneficial one. Almost immediately after the completion of one of these properties I was able to either resell or find a desirable tenant, a tenant of a different class, one who was always able to pay his rent in advance, and some of the houses already constructed to which I added bath and kitchen sinks at a cost of about $200, I was able to increase the rents on these properties $5 and $6 per month and in addition to this advance in rent had a much better class of tenants.

I always found it advisable in figuring the cost of construction first to figure the cost of the modern conveniences, as they were the essential selling points of the house. And if, for any reason, it became necessary to lower the cost of construction, to do so either in the size or finish instead.

I erected several houses in your city of the following size which were somewhat compact although proved to be very attractive to the average buyer, as well as to the larger per cent of tenants. The foundations were 24x30 ft., basements under entire house; first floor containing living room, dining room, kitchen, pantry, front and back porches. Second floor containing three bed rooms, hall and bath with four large closets. My experience is that the home builder or investor, in order to get the best results from his investments, or quick returns by reselling, must install the modern conveniences and especially the bath and kitchen sink.

Yours truly,
W. E. BUNGER.

First Post Card.—A little later we sent a post card to which was attached a high grade pencil, on which was stamped "Compliments of the Terre Haute Water Works Co.—Pure, Filtered Water, Low Rates." The message on the post card was as follows: (Two pictures were shown, one of a figure tied to an outdoor pump over a surface well, the other of a figure drawing water at a kitchen sink.)

Look at the two pictures; they are so different. With city water in the kitchen it is not necessary to work the old pump in all kinds of weather.

Several years ago, there was a scarcity of houses to rent in Terre Haute and many people were compelled to take undesirable houses. They wanted and were willing to pay for good houses, but could not get them. There are plenty of vacant houses now. Naturally, the people who pay rent will take the most desirable houses. With two houses to choose from, one with a kitchen sink and city water and one without, other conditions being practically the same, it does not require a prophet to guess which one will be taken and which will remain vacant.

Now, there are many houses in the city that are desirable from many standpoints, but are lacking in one important point—they are not provided with city water.

Modern, medium sized houses are in demand. The long-headed, progressive landlord can see beyond today and realize that it is better to keep his tenants satisfied and that regular rent payments are preferable to empty houses. The empty house earns no money.

Delays are sometimes expensive. Why delay and take chances? Why not act now?

TERRE HAUTE WATER WORKS CO.

Second Post Card.—After waiting a while another post card with a lead pencil attached was mailed; the message on the card was as follows: (The card bore a picture of a modern bath room.)

GET THE SPIRIT OF THE NEW AND BETTER TERRE HAUTE.

It is really surprising how much building is going on in the city. The American Realty Co. is building a lot of bungalows and you may be sure that they all are provided with city water. And they will be snapped up as soon as completed.

Go out on Third Ave. in the neighborhood of 22d St. and you will see some fine examples of modern houses—they would be a credit to any city. Every one of these beautiful new houses are provided with city water. These are the kind of houses that are in demand.

Renters want bath rooms and they take the houses that have them. The use of a bath room with city filtered water is conducive to health and pleasure, especially in cold weather. It is a great convenience to have hot and cold running water in the house. In the stage-coach-rain-barrel-kerosene-lamp days people would bathe in a washtub, carrying the water in and out—but it's different now—and the successful, progressive landlord realizes it.

Many houses without bath rooms will be left empty. There are many houses in Terre Haute that can be made desirable by the addition of city water, a bath room and a few improvements. Owners of old houses who fixed them up and put in bath rooms get a good rate of interest on the additional investment and secure a better grade of tenants.

When you use the pencil we are sending you, just think "city water and bath room." Remember, the empty house earns no money.

We are ready to help you in planning arrangement of pipes and to make suggestions that may be valuable, without cost to you.

Get the house fixed up before cold weather comes.

Think it over and start something.

THE TERRE HAUTE WATER WORKS CO.

Both telephones, No. 215.

Third Post Card.—The third and last card sent was entitled "A Story About Indians." The text was as follows: (This card also showed a picture of a modern bath room.)

A Short Story About Indians, by Miss Bingham, appeared recently; it is as follows:

"Some Indians who had never been away from their forests, spent several days viewing the triumphs of civilization in a big city. And the thing which surprised them most was not the heighth of the

> buildings nor the gorgeous display of city stores, nor the trolley lines and moving pictures, but the fact that any minute the people chose they could turn a faucet and get all the water they wanted.
>
> "Those Indians knew what it meant to need water and to search for it; they knew that it was a necessity of life. And it seemed wonderful to have this gift of life right at hand—always with them."
>
> And It is wonderful!
>
> Filtered water service in the kitchen and bath room, as furnished In Terre Haute, is as superior to the old-style way of getting water out of a well, with privy vaults close by, as electric light is superior to the candle; as the ocean greyhound is superior to the sailing vessel; as a Pullman Palace Car is superior to the old ox cart.
>
> Why wait longer for this great convenience? Why not put the pipes into the kitchen, at least, before cold weather?
>
> By doing this now, many, many trips to the old pump would be saved. Don't keep the good wife tied to the pump any longer.
>
> Try this different way of getting water—this better way, this modern way, this labor-saving way.
>
> Call up some plumber today, or several of them, if you please, and get the benefit of competition. We will be glad to advise with you, without any cost, as to the best method of arranging pipes.
>
> The opportunity is yours; grasp it—now!—today!
>
> Yours truly,
>
> Both Phones 215. THE TERRE HAUTE WATER WORKS CO.

The idea we have in mind, in this circularizing, is that the people who are on our general list will, before many years, become customers of ours and the object is to hasten the day when they will be no longer prospects but customers; bringing money into our office to help pay expenses, interest and dividends to those who were courageous enough to put their money into a business which was not profitable in its early days.

Co-operation of Water Works Supply Firms.—In addition to the printed matter which we have been sending out, we secured the co-operation of such enterprising supply men as the Standard Sanitary Mfg. Co., the H. Mueller Mfg. Co. and the Crane Co. We furnished the prospect list to each of these concerns and they mailed printed matter. It was very refreshing to have these supply men assist in the publicity campaign; they are out for business and are willing to spend some money to get it. One of the supply men went so far as to offer to send a special representative to interview those who replied to their printed matter. The letter sent by one of the supply men is so good that I will give an extract from it, as follows:

> Some day ere long in your home you will have city water—the greatest comfort and convenience known in modern life.
>
> Instead of having to heat water and make special preparations every time you want to bathe, and then perform that duty under discomforting and inconvenient conditions, you'll walk into your cozy bath room with its inviting white tub and hot and cold water, disrobe and plunge in. Oh, the joy of it, the luxury and satisfaction! It's no longer a duty—it's a real pleasure now.
>
> And when you want water in the kitchen you will merely turn the faucet and get it hot or cold. No more trudging out in the back yard to pump or draw it from the well, with the rain, snow and wind beating down on you mercilessly.
>
> Those days of slavery will be only an unpleasant memory. Modern domestic engineering and sanitary plumbing have secured your emancipation.

Our solicitor then made a second call on those whose names appear on our prospect list; he set forth the idea of making water connections before cold weather, also that we pump water for their neighbors and would like to pump a little for them.

Summary.—In arranging this publicity campaign, I was impressed with the importance of getting a list of prospects so that our promotion work would be done where results were possible and probable. Will a publicity campaign like this bring results? Let us sum it up before answering. Here are Mr. and Mrs. Prospect with a fairly good house without running water in the kitchen and bath room.

First, a courteous and agreeable gentleman calls and tells them of the advantages of city filtered water.

Second, the letter carrier brings a letter telling of the advantages of a bath room from the investment standpoint.

Third, a second letter arrives with copy of letter from a successful real estate man telling why he put in bath rooms.

Fourth, the carrier brings a large postal card (with pencil attached) urging prompt action and showing with cuts the difference between the back yard pump and running water in the kitchen.

Fifth, the carrier delivers another card with cut of bath room and suggestion that when the pencil which is sent, is used, to think "City Water and Bath Room."

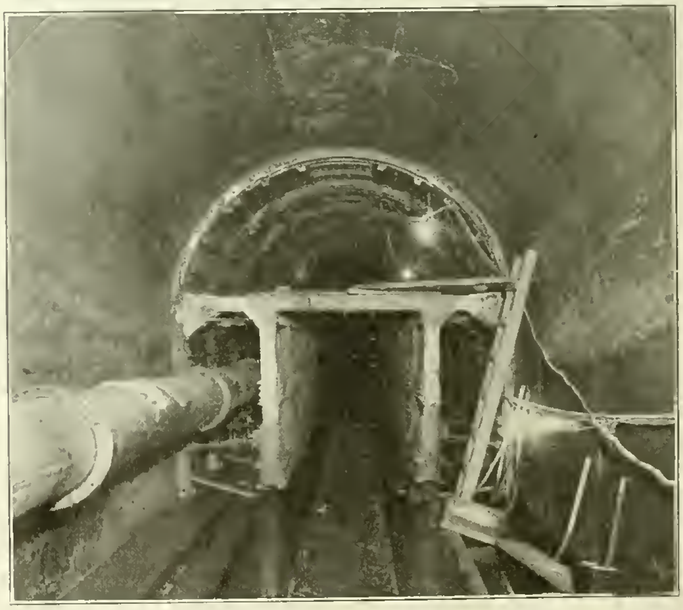
Sixth, postman brings a still larger card with cuts and arguments in favor of a bath room.

Seventh, the smiling solicitor makes a second call. And all of these are followed by still further visits of the postman bringing letters and pamphlets about bath tubs and other plumbing goods. And even this is not all for if Mr. and Mrs. Prospect can withstand all that has preceded, they are bombarded with still more letters and printed matter.

Therefore, if I know human nature as well as I think I do, if suggestion upon suggestion and then still more suggestions will cause people to act, I am sure that our publicity campaign will bring good results and be a profitable investment.

LINING THE WILSON AVENUE WATER SUPPLY TUNNEL AT CHICAGO BY PNEUMATIC MIXING AND PLACING.

The Wilson Avenue Intake Tunnel, which is now being constructed by the city of Chicago, is 8 miles long and has a finished section 11 ft. 4 in. wide by 12 ft. in height and contains a concrete lining from 1 ft. to 18 in. in thickness. This tunnel is excavated in solid limestone, about 160 ft. below the lake level and extends a distance of 14,000 ft. into the lake to the crib, and about 28,000 ft. under Wilson Avenue to the pumping station at Mayfair.


Forms and Pipe Line for Pneumatic Lining of Wilson Ave. Tunnel.

The tunnel is being constructed by the city, on a day labor system and remarkable progress is being made, both in the excavation and lining. There are four working shafts, one being at the lakeshore, the 14,000-ft. heading being driven from this shaft, and the other three shafts being located about equal distances apart on the land section. There is also a shaft at the crib, but this is not being used for the tunnel excavation and will be completed at about the time the tunnel excavation from the shore reaches it.

The progress of excavation in the tunnel at each shaft has averaged about 20 lin. ft. per day. The excavation has been prosecuted by the top heading and bench method. The bottom heading method was tried from one shaft, but it was shortly abandoned. One of the very interesting features of the work is the use of the material excavated for constructing the concrete lining. The solid limestone rock is carried in cars from the heading to the pneumatic concrete mixing and conveying plant and is here passed through a 4-in. screen. The rejections from this screen are shoveled into a car standing alongside, and taken out of the tunnel. The balance of the material falls onto a belt conveyor which deposits the material into the measuring hopper located just above the pneumatic mixer. This hopper holds ½ cu. yd. batches and cement is added here just prior to dumping the hopper into the mixer. This is probably the first time a tunnel of this size has been lined simultaneously with the driving and using the excavated rock for the concrete, without taking the rock out of the tunnel. The excavation in the heading had progressed about one mile before the concrete work was started in each shaft. The balance of the excavated material could therefore be used for the concrete work which progressed at the rate of 60 ft. per day while the excavation progressed at the rate of 20 ft. per day.

The concrete mixer and conveyor, and the belt for loading the mixer, all occupy one narrow-gage track, leaving another narrow-gage passing track so that there is always a clear track through the tunnel. An 8-in. pipe leads from the pneumatic mixer and conveyor to the forms. There are two sets of Blaw traveling forms, each 30 ft. in length. The mixer is first set 800 ft. from one set of forms, and 400 ft. from the other set of forms. These forms are then concreted alternately and moved toward the mixer. When the concrete work has progressed as far as the mixer it is then moved on its wheels another distance of 800 ft. and the operation is repeated, making another cycle. The forms are built so that a single narrow-gage track passes through the center, and clearance is sufficient to permit the passage of the gasoline locomotives and cars. The 8-in. pipe line is laid along the side of the track so that it also clears the locomotives and cars. The narrow-gage track which passes through the forms is a temporary track leading from the mixer through the forms and this track is taken up and moved 800 ft. at a time corresponding with the movements of the mixer. The temporary track is laid on the center line of the tunnel, and the ties, which are steel, are simply laid right on top of the rails of the permanent double track through the tunnel.

It would not have been possible to concrete this tunnel simultaneously with the excavation, by any other method than the pneumatic method, and if another method had been used the excavated material would all have been removed from the tunnel and that used for concrete would have had to be taken back into the tunnel. The time for completion of the tunnel has been reduced by about one year by the use of this method. It was first estimated that the construction period would cover about 42 months, but the present progress indicates that the work will be complete in about 30 months.

The number of men required in the concrete work is as follows: Two men pushing cars to the conveyor; three men shoveling from screen; one man handling hoist; two men dumping cars; three men handling water and cement and dumping measuring hopper; one pneumatic mixer operator; two men at the forms.

One gang comes on at eight o'clock in the morning and finishes its 30-ft. form by from one to three o'clock in the afternoon. A second gang comes on at eight o'clock at night and does the same in the other form. Then there is a form moving gang, consisting of four to eight men, which divides its time between the two forms, moving them about 12 to 16 hours after the concrete is set. This single gang takes care of both forms, moving them and erecting the sandbag bulkhead, and getting ready for the gang. In this way 360 ft. of tunnel is concreted each week, and every second Sunday a machine is moved, which makes about 720 ft. of tunnel completed every four weeks at each shaft.

The working out of the plan for applying the pneumatic method to the work was under the direction of Mr. Henry W. Clausen, Engineer of Water Works Construction; and the apparatus for mounting the pneumatic mixer on wheels and for the belt conveyor loading apparatus was designed under Mr. Clausen's direction, with the cooperation of the Concrete Mixing & Placing Co., the lessors of the pneumatic mixers and conveyors, 123 W. Madison St., Chicago.

PRACTICE OF PEORIA RY. CO., PEORIA, ILL., FOR PAVING STREET RAILWAY TRACKS.*

By R. F. Dalmblade, Chief Engineer, Peoria Railway Company.

In our later track rehabilitation work, we have endeavored to adhere to the following principles: First, that the subgrade must be adequately drained; second, that the track itself must be resilient to a certain degree; third, that on both sides of each rail a longitudinal expansion joint must be provided, and, lastly, that the rail joint must be of a permanent and lasting character.

All these are factors directly affecting the life of the pavement. In conformity with these principles, we constructed in 1913 a double track on a part of Adams St. in which we used the following: A drainage system, crushed stone ballast spread in layers and rolled, creosoted ties, a concrete paving foundation, special reinforced rail joints with heat treated bolts of a high elastic limit, a 1-in. sand cushion, together with a creosoted wood block pavement with longitudinal expansion joints on both sides of each rail and transverse expansion joints every 10 ft. This particular track, though subjected to heavy traffic, has as yet given no evidence whatsoever of failure at the joints or along the rail. The block pavement has not been disturbed in the least, it having been our experience that track failure in an early stage is first indicated by slight rupture of the pavement.

We have abandoned entirely the use of concrete under the ties in our track construction, though we do use concrete for paving foundation, beginning at the bottom of the tie and extending 8 in. toward the surface of the street. This paving foundation is deep enough to embed the ties and a portion of the rails, thus forming a comparatively solid mass, resting on a rock or gravel ballast cushion of some elasticity. This type of construction has eliminated most of our pavement troubles.

Track pavements usually commence to fail in close proximity to the rail joint, due to the joint itself, yet rail joint troubles have acted as a spur to the development of various types of improved rail fastenings. More recently, on our rehabilitation work, we have been using an electrically welded joint in connection with an electrically driven track grinder; the idea being to obtain a perfectly smooth running surface where the rail ends meet.

We have recently completed about 1½ miles of double track, which included three different types of pavement, using our method of standard construction with the welded joint, up to the paving stage. A quarter of a mile of this track was paved with brick, an asphalt filler being used; another piece of this track was laid with brick, using a sand filler and approximately a mile was laid, using a grout filler. In the last instance a patent expansion joint, ¼ in. thick by 4 in. in depth, was laid along both sides of each rail and transverse joints were placed every 10 ft.

We understand that the paving commission of Baltimore, Md., has specified that along the outer rails of street railway tracks a bituminous filler be used similar to the one just mentioned. In our case, the patent joint is easy to install and no doubt fulfills some of the purposes for which it was designated, i. e., the elimination of the trouble caused by the friction of the pavement against the rails and the function of an expansion joint.

An ideal pavement for street railway tracks in cities of moderate size would no doubt have as a general foundation a roadway incorporating the specifications outlined below, which is an excerpt from our standard track construction:

All double track is laid with 10-ft. 6-in. track centers. After the rail grade has been established, the roadway is excavated to a depth of a 21-in. and 4-in. vitrified sewer tile laid with open joints down the center of each track at a depth of 12 in. below the bottom of the trench. If the track for a distance is level, a suitable fall is provided for the tile into the city sewer system. The tile is then covered to the level of the sub-grade with gravel or fine broken stone and the sub-grade thoroughly rolled with a 5 or 6-ton roller. Risers or cast iron hand holes are provided at each street intersection. Five inches of 1½-in. to 1-in. crushed stone or gravel are then spread level over the sub-grade and also well rolled with a roller; 6-in. by 8-in. by 8-in. oak creosoted ties are then laid with 2-ft. centers on the level rock, the tie plates and rails laid and spiked, after which a sufficient quantity of fine broken stone is scattered between the ties to raise the track and tamp same to grade. This allows about 8 in. of ballast. A standard 60-ft. 7-in. rail has been adopted, which is a groove section and weighs 97 lb. to the yard. Special reinforced chanel bars are used. The rails are laid with staggered joints and 1-in. tie rods used, the spacing being 7½ ft.

---

*From a paper presented at the last annual meeting of the Illinois Society of Engineers and Surveyors

The joints are drilled 6-hole standard, all plate and web holes for bolts being drilled slightly smaller than 1 in. The holes are then reamed to 1 in. in diameter and a 1-in. turned, heat treated, high tensile strength machine bolt is used. It is obvious that a driving fit is necessary, after which each bolt is pulled up snug and marked to prevent loosening.

A 10-in. 4/0 capacity concealed compressed terminal bond is used under the joint plates and when double track is being built, the joints on the two inside rails are bonded with an outside 36-in. 4/0 compressed terminal bond in addition to the concealed bond. Cross bonds of 4/0 or more in capacity are installed every 400 ft.

Concrete in the proportion of 1 cement, 3 sharp sand and 6 broken stone (concrete size) is then poured over the ties and between them to a depth of even with the bottom of the ties, or about 8 in. The concrete is thoroughly shovel-tamped under the edges of each tie in order that the concrete might grip the tie firmly. A rail plaster of sand and cement in proportion of 1 cement and 4 sand is then placed under the groove and head of the rail and smoothed down perpendicular to the projecting edges.

A sand cushion of 1 in. is then spread over the solid concrete and either brick or wood pavement laid on same, the type of paving being designated by the city.

The paving, if left to our choice, is of standard vitrified brick and an asphalt filler is used in addition to the patent expansion joint mentioned previously. All brick in the right of way is laid transversely with the line of the street. We do not use the so-called stretcher brick, neither do we use a nose brick.

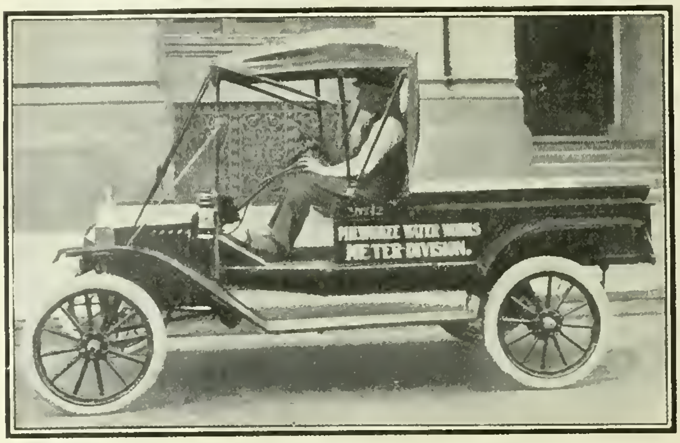
To provide a smooth runing surface each rail joint is ground perfectly smooth, it having been found that in rolling rails at the mills a slight difference in the heights of the rail ends occur, which in time allows the car wheels to batter down the receiving rail and ruin the joint, together with the adjacent pavement. In 1915 we used the electrically welded joint to the exclusion of all others on our construction work.

MOTOR CARS FOR FIELD WORK, METER SETTING AND REPAIRS, MILWAUKEE WATER WORKS.

For the field work of the Division of Meters, viz., new meter settings, removal and resetting of old meters, repairing meters on premises, and emergency calls, the Division now has six automobiles, two of which were purchased and placed in service during 1915. This motor vehicle equipment consists of two ¾-ton KisselKar trucks, three Ford trucks and one Ford runabout. The superiority of the service obtainable from this equipment over the old horse drawn vehicles is too plainly evident to need any comment.

In December, 1915, each of the four Ford cars was equipped with demountable rim wheels of standard size, and spare tires. This was done to increase the efficiency of the cars by reducing the item of time lost in making temporary repairs on road in the event of punctures, and to overcome the necessity of carrying in stock two sizes of tires for the same machine.

The additional cars placed in service during the past year have materially assisted in increasing the efficiency of the Division, and rendering service to the consumers. One of the cars (Runabout No. 10) is in constant use attending to complaints of meter leakage and stoppage. The operator of this car is an experienced meter repair man and makes repairs of meters wherever possible, on the premises, or brings the meter to the shop for bench work. The other car (Truck No. 12) is used exclusively in field repair work. The operator of this car, also an experienced meter repair man, does all field repair work and on account of decreasing the "road" or "travel time" is able to do the work formerly assigned to three men. Attached is a table showing the mileage and cost of operation of each car for 1915.



Motor Car Used by Meter Division.

Irrigation System in Reeves County, Texas.—A considerable amount of construction is being undertaken this season by irrigation districts in Texas. One of the latest projects to come up for bids is that of Reeves County Irrigation District, No. 1, of Balmorhea. This district is located in the western part of Texas, on the eastern slope of the Davis Mountains, partially surrounded by foothills. The Pecos Valley Southern R. R. traverses the entire length of the irrigated district. The district was organized a short time ago for the purpose of purchasing the old irrigation system belonging to the Toyah Valley Irrigation Co., and now proposes to increase the present water supply through the construction of a storage reservoir and the conservation of the flood waters of Toyah Creek and the winter flow of the large San Soloman Springs. The flow of these springs during the irrigation season has been used for the past 50 years and gully demonstrates the productiveness of the soil when sufficiently supplied with water.

TABLE 1.—MAINTENANCE COST RECORD OF AUTOMOBILES FOR 1915.

					Actual cost						Cost, including depreciation			
Car. No.	Days operated.	Mileage.	Gallons gasoline.	Miles per gal. Avg.	Gasoline, oil and grease.	Repairs and misc.	Tires.	Total.	Per day.	Per mile.	Depreciation.	Total cost.	Per day.	Per mile.
2........	293	5,180	770	6.73	$106.30	$388.46	$ 94.50	$ 589.26	$2.01	$0.113	$191.47	$ 780.73	$2.66	$0.15
4........	293	4,678	547.5	8.54	74.82	92.88	109.92	277.62	.94	.059	173.08	450.70	1.53	.096
6........	293	8,808	589	14.95	81.23	114.21	98.74	294.18	1.00	.033	104.68	398.86	1.36	.045
8........	293	7,970	521	15.29	71.15	124.51	83.63	278.69	.95	.034	95.62	374.31	1.27	.046
10........	256	9,668	510	18.95	69.22	40.66	69.61	179.49	.70	.018	115.99	295.48	1.15	.030
12........	229	6,320	348	18.16	48.19	24.92	52.87	125.98	.55	.019	75.86	201.84	.88	.031
				Avg.					Avg.	Avg.			Avg.	Avg.
Total...	1,657	42,624	3,285.5	12.97	$450.91	$785.64	$508.67	$1,745.22	$1.05	$0.040	$756.70	$2,501.92	$1.51	$0.058

Current Engineering Practice Briefly Recorded

UNIT WELLS AT LINCOLN, NEB.

Contributed by Paul W. Doerr, Assistant Superintendent, Water and Light Department, Lincoln, Neb.

Figure 1 shows the exterior of one of the well houses which are located within a radius of 3,000 ft. of the main pumping station of the Lincoln water works. All of these well houses have removable roofs, and a steel frame work for hoisting purposes is attached to the roof of each house. These hoisting frames are used in removing the heavy parts of the motor and pump units when it is necesary to make major repairs.

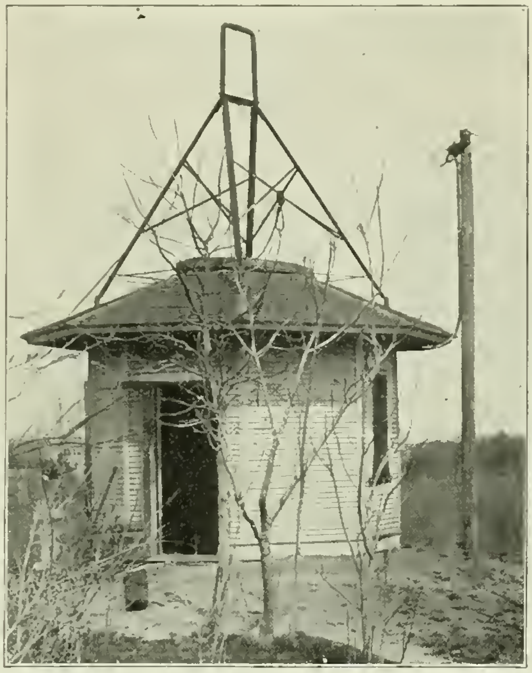


Fig. 1—Exterior View of Unit Well House, Lincoln, Neb.

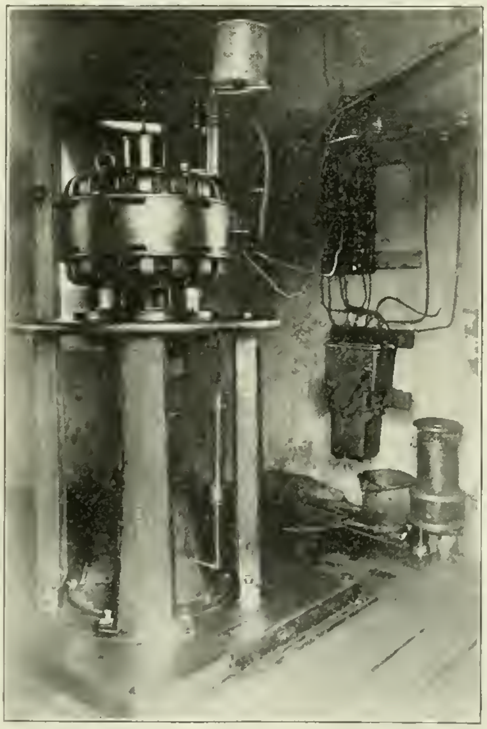


Fig. 2—Interior View of Unit Well House, Lincoln, Neb.

Figure 2 is an interior view of one of these well houses, and shows the electric motor mounted on the framework of the pump. The well is about 200 ft. deep and 10 in. in diameter. Pumps are electrically driven and operated, either from the main station or from the switch in the wellhouse. The pump has a capacity of 800,000 gal. per 24 hours. After the water is brought to the surface it flows into the large concrete reservoirs near the main station, where it is again pumped directly into the main by the steam operated plunger pumps. This style of a pump has proven very satisfactory in our pumping system on account of the low operating cost and the small investment necessary to deliver such a large quantity of water. The complete cost of pump, well and wellhouse is a little less than $4,000. The pumps are of American Well Works (Aurora, Ill.) manufacture.

CONCRETE COTTAGES FOR EMPLOYES, WHITLINGHAM SEWAGE FARM NORWICH, ENGLAND.

By Frank C. Perkins, Buffalo, N. Y.

Some unique concrete block cottages were recently built at Whitlingham Sewage Farm, Norwich, England. The blocks were molded on the site on a Winget machine, the gravel being taken from the farm. The cost of the cottages was about the same as if they had been built of local brick—perhaps somewhat less. Approximately the total cost, including the blocks, was about £1,700 ($8,000). The cottages were designed by Mr. Arthur E. Collins, M. Inst., C. E., city engineer of Norwich, England, to whom the writer is indebted for particulars and illustrations.

When these concrete cottages were completed the contract amount for building was £1,350 (about $6,000), not including the materials for walls, consisting of cement concrete blocks molded on the site from ballast close at hand by means of a concrete block molding machine. The cost of the blocks was about the same as local bricks; the latter would have had to be carted about three miles. The block comprises six cottages each containing a parlor, living room, scullery, coal-house, pantry and water closet on the ground floor and three bedrooms on the first floor, excepting each end house which contains four bedrooms on the first floor. A bath is placed in the scullery covered with a hinged table top. Hot water is supplied from the clothes boiler, also in the scullery. Each cottage is provided with a small tool house, also large front and back gardens.

Concrete Cottages for Employees of English Sewage Farm.

It may be stated that the concrete blocks are 2 ft. 8 in. x 1 ft. 4 in. x 4½ in. thick, the external walls being hollow comprising two 4½-in. concrete block walls tied together at about 3 ft. intervals in both directions and with a 2¼-in. cavity; the party walls are 9 in. and the partition walls 4½ in., also of concrete blocks. Red brick quoins are built at the angles and the lintels are faced with layers of red tiles in cement. The roofs are covered with Norfolk sand-faced pan-tiles on reeds grown on the river bank. The ground floors are solid, consisting of a 3-in. layer of broken brick, a 2-in. layer of cement concrete and a 1-in layer of breeze concrete; the latter is floated with hot pitch composition and 1-in. floor boards are nailed down. The water supply was laid and the sewage treated on the sewage farm. The cottages are much appreciated by the tenants who are sewage farm employes and pay a uniform rent of 2s (50 ct.) per week.

LIQUID CHLORINE PLANT FOR SAN JOSE, CAL., WATER CO.

Contributed by P. D. Rice, Engineer, 374 West Santa Clara St., San Jose, Cal.

This company installed three liquid chlorine water treatment plants upon its various sources of surface supply about one year ago. Occasional bacteriological tests theretofore made indicated some slight pollution and it was therefore decided as a precautionary measure to make the installations referred to.

Chlorine House, Serum House and Control Board and Absorption Tower, Tisdale Reservoir, San Jose Water Company.

These plants have since been in practically continuous operation, weekly examinations of both raw and treated waters being made in our own laboratory, with occasional check tests by the laboratories of the State Board of Health. Broadly speaking these tests indicate slightly polluted raw waters which are rendered practically sterile by treatment, reductions of 98 per cent in bacterial counts not being uncommon. The rate of dosage has in no case exceeded 2 lb. of chlorine per 1,000,000 gal. of water, and at certain seasons less than this has been found effective.

We are unable to give any data on the influence of treatment upon the typhoid rate as San Jose has never had a case of typhoid which was traceable to or even attributed to the water supply. The County health officer assures us that there has never been an indigenous case of typhoid in San Jose for a number of years and that within the corporate limits of San Jose there have been not more than six cases all told within the last ten years.

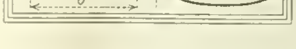
A HOME DEVISED MACHINE FOR BUILDING RESERVOIR EMBANKMENT.

In building embankment for the Hiland Avenue Reservoir at Pittsburgh, Pa., a novel device described by Mr. Emile Low was employed. This machine consisted of a large box, supported by two pairs of wheels, and drawn by three horses. This box held about 1 cu. yd. At the front end, there was a slat elevator, operated by cogs and pinions. At the bottom of the elevator there was a scoop-shaped plow. The material was loosened by this plow and then forced upon the elevator and carried into the box. When the latter was full, the scoop or plow was raised and the whole machine was hauled to the embankment. The bottom of this box consisted of a number of hinged slats, which, when turned, allowed the material to drop out gradually, forming a layer of about 4 in. This machine proved an ideal one for building the embankment, first on account of the thin and even layers deposited, and, second, on account of the consolidation of the layers by the passage of the heavy loads over it. Notwithstanding this, rolling with the prescribed heavy grooved roller was never omitted, although it seemed at times to be a senseless requirement.

SHOOTING SOOT FROM STACKS.*

By S. R. Russell.

In many industrial plants there are often large smoke or kiln stacks. These stacks often become clogged or partly so on account of the soot adhering to the inner lining. It is necessary in order to maintain draft that the stacks be cleaned frequently. A simple, economical and most efficient method to accomplish this is to shoot the stack with the "Stack Gun" and Du Pont FFF blasting powder. This gun can be used in cleaning either lined or unlined stacks, brick or steel, without any fear of injury to the stack or lining.



The gun can be made out of an old piece of shafting about 4 in. in diameter and 14 in. to 16 in. long. Bore a hole 1¾ in. in diameter and 10 in. long in the center of the piece. Then bore a small horizontal hole ¼ in. in diameter through the piece to the bottom of the center bore. This hole serves as a touch hole for inserting the fuse. The whole thing can be mounted on a pedestal about 6 in. in diameter so that it will stand in an upright position.

The method of operation is as follows: Pour blasting powder into the mouth of the cannon to about 2 in. from the top. Tamp to the collar with dry clay. A short piece of fuse is inserted in the touch hole and in contact with the main powder charge. Open the flue door at the bottom of the stack, set the cannon on the bottom and in the center of the stack, light the fuse and close the flue door. The explosion shakes and loosens the soot adhering to the sides, causing it to fall to the bottom. It can then be removed through the flue opening.

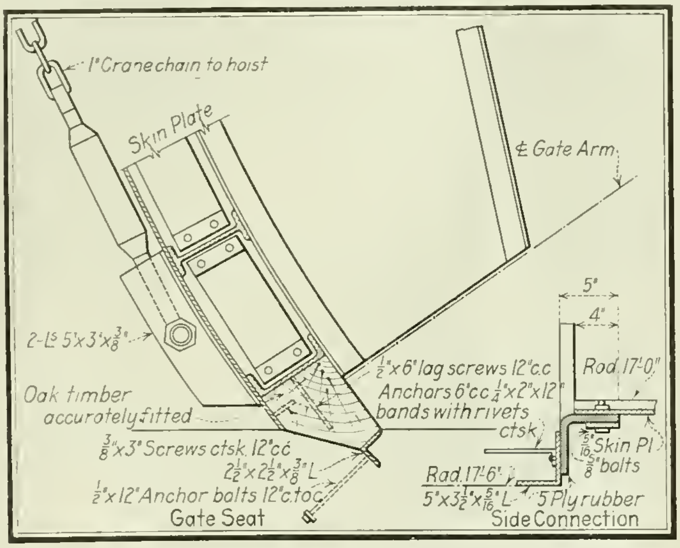
---

*Du Pont Magazine, Wilmington, Del.

A charge of 8 in. of FFF powder, 1¾ in. in diameter, is sufficient for a stack up to 100 ft. high, and 4 ft. in diameter, or over. The number of shots necessary to thoroughly clean a stack depends upon its condition. Ordinarily three or four shots will clean a stack, but if very dirty it may require more. The size of the charge and length of the cannon can be regulated to suit the height and diameter of the stack. There is no doubt about the efficiency of this "gun" for cleaning smokestacks. One of the largest manufacturing concerns in the country has used this method for several years, without an accident or injury in any way to the stacks.

TAINTER GATE SEAT AND CHAIN CONNECTION.

A simple design for the seats and the chain connections of the Tainter gates designed for the Fort Dodge, Iowa, hydroelectric plant is shown by the accompanying drawings. The gates are 20 ft. long and 15¾ ft. high vertically hinged to and working between concrete piers on the spillway crest in the usual manner of such construction. A notch in the spillway crest is faced with an anchored angle, and a similarly anchored angle is set into the face of the pier along the arc of travel of the gate face. All other parts of the gate seats and side seat are attached to the gate and the drawings show the details. The engineers of the plant are Burns & McDonnell, Kansas City, Mo.



Taintor Gate Seat and Chain Connection Detail.

CLOSELY SPACED PILES IN AN OLD STACK FOUNDATION.

In wrecking the old buildings to prepare the site for the new terminal of the Delaware, Lackawanna & Western R. R., at Buffalo, N. Y., the old stack foundation shown in the accompanying illustration was uncovered. This foundation is an interesting example of close pile driving, as it contains approximately 200 piles, although only 20 ft. square. We are indebted to G. E. Boyd, division engineer, D., L. & W. R. R., for the view shown.

METHOD AND COST OF USING VALVE INSERTING MACHINE, LINCOLN, NEB., WATER WORKS.

Contributed by Paul W. Doerr, Assistant Superintendent, Water and Light Department, Lincoln, Neb.

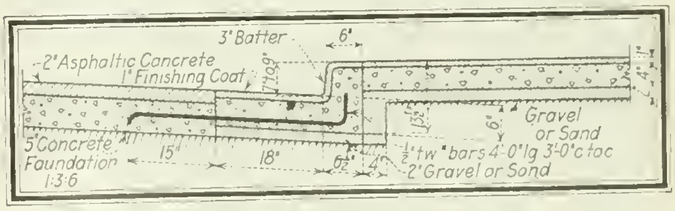
The valve inserting machine used by the Lincoln city water department has been in use for about one year, and the results have really been beyond our expectations. We have found this machine invaluable in making repairs to broken hydrants. In the early days of the department, hydrants were set without putting valves on them and we now have something like 200 hydrants without gate valves. These hydrants are all being equipped with a separate valve.

The valve inserting machine consists of three castings, which are set over the main at the point where the valve is to be inserted. The cutter is put on before the castings are clamped on and pipes partly cut, to be sure that the cutter is cutting equally on both sides of pipe to be cut out. When this is done, the upper castings are bolted on and a ratchet attachment connected with the cutter is operated from above. Then when the main is cut through, the cutter with the piece of pipe cut out is elevated and a sliding gate valve, just above the main, closed. The top plate is removed, bringing out the cutter and the piece of pipe cut out. After this operation, the valve is inserted and is let partly down and covered again and bolted on. Then the sliding gate valve is opened and a valve put in place where the piece of pipe was cut out, and the sliding sleeve on one side is forced against the valve with two jackscrews, which are a part of the machine. When this is done, the castings are removed and lead is run into joints, to make it a permanent installation.

The work of inserting valves is done by two men, equipped with a tripod crane and a four-wheeled truck on which they put the machine and tools in order that they may be transported from place to place. The average cost of the department for making a 4-in. insertion, which includes all special material, all labor, such as back-filling, lead, yarn, etc., in paved streets, is $52.65 each; for making a 6-in. insertion, $56.83 each, and for making an 8-in. insertion, $77.47 each. We further find that the most economical way to have these insertions made is to put two men on this work and keep them at it until all the valves on hand are inserted, for they soon familiarize themselves with all small details pertaining to this particular machine.

A METHOD OF ANCORING PAVEMENT BASE TO CURB AND GUTTER.

The drawing shows a method recently adopted at San Antonio, Tex., to prevent separaton of concrete base from combined curb and gutter. Owing to a subsoil which swells and shrinks with changes of moisture content concrete base for pavement in San Antonio has cracked excessively. So great indeed has been this trouble that in recent practice concrete base is reinforced with wire mesh. Another trouble has been the parting of the base concrete from the combined curb and gutter. Frequently the crack opened has been 2 in. in width. To remedy this trouble the construction illustrated has been employed. The drawing shows all essential features. After a year no separation appears on the first pavement in which this anchorage method was employed. Mr. Hans Helland is City Engineer of San Antonio.



PERSONALS.

H. O. Hickok has been appointed county engineer of Marshall County, Iowa.

Monty Hulse, Tacoma, Wash., has been appointed city engineer at Sumner, Wash.

S. R. Titus, city engineer of Arkansas City since July 1, 1911, has resigned that position.

Mr. O. J. S. Ellingston has been appointed city manager of Sherman, Tex. He formerly was city engineer of that city.

A. F. Macallum, city engineer of Hamilton, Canada, has accepted an appointment as Commissioner of Works at Ottawa.

Howard Weiner, Wilkes Barre, Pa., has been appointed forester of the Wyoming Valley Water Supply Company of Hazleton, Pa.

James E. Little has been promoted to chief engineer of all the ore interests of the Bethlehem Steel Company. He was a mechanical engineer of the Spanish-American Iron Company of Felton, Cuba.

R. Henderson Rivers, Louisville, Ky., has resigned as first assistant to the county engineer, effective June 1. He has decided to go into the contracting business and has a contract for work to be done in Whitley County.

Mr. Emil Diebitsch, former president of the General Contractors' Association of New York City, has been elected commissioner of the town of Nutley, N. J. He will serve as Mayor-Commissioner of Public Affairs, Streets and Public Improvements.

Mr. Fred C. Dunlap, formerly chief of the Bureaus of Water and Filtration, Philadelphia, Pa., has been retained by the city as consulting mechanical engineer for advice in connection particularly with the design of certain parts of the Frankford Creek intercepting sewer.

Ward B. Perley has been appointed vice-president and general manager of the newly-organized Canadian Steel Corporation, which as a subsidiary of the United States Steel Corporation will build and operate the new works at Ojibway, a short distance across the channel.

Mr. J. C. Allison, heretofore assistant general manager and chief engineer for W. H. Holabird, receiver for the California Development Co., will on June 1 open offices in Anderson Bldg., Calexico, Cal. where he will engage in general engineering practice, specializing in irrigation, drainage, silt investigation, municipal engineering and valuations.

Mr. William von Phul, vice-president and general manager of the American Autos Co., and a member of the firm of Ford, Bacon & Davis, will succeed Mr. Charles N. Black as vice-president and general manager of the United Railroads of San Francisco. Mr. Black will hereafter devote all his time to the interests of Ford, Bacon & Davis, of which firm he is a member.

Howard E. Hyde, formerly acting city engineer of Manila, and for many years principal assistant engineer of the sewage system and street paving work at Havana, Cuba, has resigned his position in connection with the New Water Works for Providence, R. I., and will after June 1 become actively interested in Young & Hyde, Inc., contracting engineers, Produce Exchange building, New York City, with which company he has been indirectly connected for the past four or five years.

OBITUARY.

Henry Rohwer.

Henry Rohwer, one of the best known railway construction engineers in the country, died May 4 at his home in St. Louis, Mo., of sclerosis of the arteries. Mr. Rohwer was born in Holstein, Germany. He was educated at Dr. Jessen's Polytechnic Institute, Hamburg, and at the Royal Polytechnic School, Hanover. He came to the United States in 1869. He began his engineering work in this country as topographer with the Burlington & Missouri Railroad in Nebraska, later becoming engineer in charge of location and construction. His next position was that of resident engineer of the Omaha & Southwestern Railway, with headquarters at Omaha, and when this road was transferred to the B. & M. Railroad he was appointed chief engineer of the latter railroad. From 1875 to 1876 he was engaged in private practice as consulting civil engineer and architect, with offices in Omaha, Nebr. From 1877 to 1881 he was city engineer of the latter city and in this position inaugurated street improvements and paving. He also planned and supervised sewerage and water works and established grades over the entire city. In 1881 he again went back to railway engineering, and from that date to 1884 was engineer in charge of location and construction with the Oregon Short Line, then a branch of the Union Pacific R. R. He had charge of and personally supervised the construction of Hodges Pass tunnel at the crossing of the Uintah range of the Wasatch Mountain; later he was promoted and acted as resident engineer. He resigned in 1884 and resumed his consulting engineering practice at Omaha. During this time he patented the "downdraft" and made improvements on continuous brick kilns and erected several large plants in Omaha and the state of Nebraska. From 1885 to 1887 he was engineer in charge of location and construction of the Omaha Belt Railway and the Missouri Pacific extension to Lincoln, Nebr. From 1887 to 1901 he was engineer in charge of maintenance of the Missouri Pacific Railway and branches, with headquarters at Sedalia, Mo. From 1901 to 1905 he was chief engineer of the Missouri Pacific Railway and the St. Louis, Iron Mountain & Southern Railway, leased and operated lines, with headquarters in St. Louis, Mo. During his tenure of office as chief engineer of the Missouri Pacific Railway system he made plans and estimates on 900 miles of grade reduction, of which about 550 miles of improvements were made. He located more than 1,100 miles of lines and constructed about 700 miles, the latter including the White River Railway, a 240-mile line, giving a low-grade route through the Ozark Mountains, with heavy construction work, including five tunnels aggregating two miles in length and many steel bridges and viaducts, the latter ofentimes reaching a height of over 100 feet. He also constructed the Memphis, Salina & Louisiana Railway, a 230-mile line, with its two large drawbridges, 440 feet and 370 feet clear spans, across the Arkansas and White Rivers, and the Eldorado-Bastrop Railway, 44 miles in length, with the Ouachita drawbridge and its two miles of trestle approach. While with the Missouri Pacific Railway he also acted as chairman of the board of engineers for the Thebes bridge, attending to location, soundings and other preliminary work. He was also a member of the board of chief engineers for the Kansas City new union depot terminals. From Jan. 1, 1905, to June 1, 1906, he was consulting engineer of the Missouri Pacific Railway system, and since June 1. 1906, has been engaged as a private civil engineer, making investigations and reports on railroads, water works, power plants, etc., and acting as consulting engineer for investors, financial institutions and municipalities. He was a member of the American Society of Civil Engineers, a charter member of the American Railway Engineering and Maintenance of Way Association, a member of the Society of German Engineers of Berlin, Germany, and a member of the Engineers' Club of St. Louis.

J. J. Mangan, Pittston, Pa., well known contractor in that section, died at his home on May 13.

James H. Mack, of Philadelphia, Pa., head of the Mack Paving Company, died at his home on May 17 after a brief illness at the age of 62 years.

Charles W. Appleby, former city engineer of New Albany, Ind., died on May 20 at the age of 36 years. He has recently been engaged in the construction of public highways in Floyd County.

NEW CATALOGS.

Dipper Dredges.—Paper, 10x7 in., 114 pp. The Fairbanks Steam Shovel Co., Marion, O.

Describes and illustrates the different types of dipper dredges and integral parts manufactured by this company. These dredges are operated by steam, gasoline and oil. Also gives numerous views of these dredges engaged in various kinds of construction work.

Cast Iron Pipe and Fittings.—Paper, 6¼x9¼ in., 104 pp. James B. Clow & Sons, Chicago, Ill.

"Pipe Economy." Gives complete information on the threaded, flanged, and hub and spigot cast iron pipe and fittings made by this company, together with data on the corrosion of steel, wrought iron and cast iron pipe. Also gives the American standard specifications for flange fittings, a list of hub and spigot water works fittings, and a full list of the company's foundry products.

Steel Pipe.—Paper, 8½x11 in., 88 pp. National Tube Company, Pittsburgh, Pa.

"National Pipe in Large Buildings." This bulletin, No. 25, is divided into two parts. The first part, comprising 53 pages, shows views of typical buildings in different sections of the country in which National pipe is used. The second part contains 24 pages of specific information and tabular data of use to architects, constructing engineers, and large building contractors. The bulletin is indexed and cross indexed to facilitate ease of reference.

INDUSTRIAL NOTES.

The Terry Steam Turbine Co., Hartford, Conn., has appointed O. E. Thomas, 626 Washington Bldg., Los Angeles, Cal., a district sales manager for Arizona and the southern portions of California and Nevada.

Mr. John Hugher, for 13 years general manager of the Steel Products Co., a subsidiary of the United States Steel Corporation, has been made assistant to President Farrell, succeeding W. D. Terley, who has been made vice-president and general manager of the new Canadian steel works to be built by the corporation.

Mr. Francis H. Wisewell, Jr., formerly connected with Westinghouse, Church, Kerr & Co., New York City, has been appointed chief engineer of the Gifford-Wood Co., Hudson, N. Y. Previous to his connection with Westinghouse, he was mechanical engineer with the Continental Car and Equipment Co., New York City.

The Central Foundry Co. announces that owing to the increasing importance of its Western business, a vice-president of the company will maintain an office in Chicago. Mr. C. C. Todd, who for many years has represented the company in the West and who about a year ago was elected a vice-president of the company, will open the Chicago office on July 1st, 1916.

The John F. Allen Co., 370-372 Gerard Ave., New York City, widely known among engineers and contractors as pioneers in the manufacture of riveting machinery, has extended its business to include a full line of high grade coal handling and elevating machinery. This department will be under the personal supervision of Charles L. D. Conklin, who for the past 20 years has been identified with the manufacture and installation of machinery of this class.

At the the annual meeting of the Cement Products Exhibition Co., held May 23, the following officers were elected: B. F. Affleck, president; A. Y. Gowen, vice-president; Blaine S. Smith, secretary; J. U. C. McDaniel, treasurer. The directors elected were the following: P. F. Affleck, Universal Portland Cement Co.; A. Y. McGowen, Lehigh Portland Cement Co.; J. U.C. McDaniel, Chicago Portland Cement Co.; Blaine S. Smith, Universal Portland Cement Co.; W. E. Cobean, Wolverine Portland Cement Co.; Wm. Dickinson, Marquette Cement Manufacturing Co.; D. McCool, Newaygo Portland Cement Co.; Robt. F. Hall, Portland Cement Association; Arthur Cameron, Municipal Engineering & Contracting Co.

Engineering and Contracting

H. P. Gillette, *President and Editor*

Volume XLV. CHICAGO, ILL., JUNE 7, 1916. Number 23.

ANNOUNCEMENT OF FOUR MONTHLY MAGAZINE ISSUES OF "ENGINEERING AND CONTRACTING."

Most of the subjects relating to civil engineering can be grouped under four general heads:

1. Roads and Streets.
2. Water Works and Hydraulics.
3. Excavation and Railways.
4. Buildings and Structures.

Hitherto we have endeavored to provide every week, or at least every other week, articles on each of these branches of engineering; but, for several reasons, it now seems advisable to concentrate the articles of allied nature in one issue each month. Accordingly, beginning the first Wednesday in July, each of the four Wednesday issues will bear one of the four titles above given and in the order given.

On July 5 the issue called the Road and Street Monthly will appear, to be followed by a similar monthly issue every month on the first Wednesday of the month. On July 12 the Water Works and Hydraulic Monthly will appear, and thereafter on the second Wednesday of every month. The Excavation and Railways Monthly will be published on the third Wednesday, and the Building and Structures Monthly on the fourth Wednesday each month.

The subscription price of any of these monthly issues of "Engineering and Contracting" will be $1, but any two or more of the monthly issues may be had for 75 ct. each per annum. All four issues (and in some months five issues), that is, 52 issues a year, will hereafter cost the subscriber $3 a year. This increase in the annual subscription price is consequent upon the much greater costs of publication. The former subscription price has barely sufficed to meet the cost of paper and printing, but, as a result of advanced prices in all lines, $2 a year was inadequate even for that part of the publishing cost.

We believe that our new monthly issue plan solves the economic problem for those readers whose incomes are such as to make it incumbent upon them to consider well the expenditure of each dollar. In the employ of every city, town, county and state there are civil engineers and superintendents in charge of public works construction and operation, at salaries far below what the importance of their positions justifies. Out of their inadequate salaries they feel bound to subscribe for one or more engineering periodicals, as well as to pay the dues in one or more engineering societies. We have consequently hesitated about adding even the slightest burden to their expense, and we believe that our new plan will, in fact, reduce the expense in most instances.

The average city and town engineer, for example, will find that two of our monthly issues—(1) Roads and Streets and (2) Water Works and Hydraulics—will give all the articles needed to keep him abreast of the times in his specialties. Sewerage—which we regard as a branch of hydraulics—will be adequately covered. Street cleaning will form part of the Road and Streets issue. Hence, at a cost of only $1.50 a year, a city or town engineer will receive, twice a month, an article service that will be adequate for his special needs.

County engineers, whose duties usually consist mainly of road and bridge work, will find the first and fourth issues sufficient for all ordinary needs. Should there be much grading—dykes, ditches, etc.—involved in such an engineer's work, it will be found advisable to subscribe also for the third issue, which will cover excavation.

An engineer specializing in irrigation may find the second issue—Water Works and Hydraulics—sufficient for his purposes. If, however, he is in charge of much "ditch" digging, etc., the third issue—Excavation—will also be needed.

A water works superintendent ordinarily needs no other issue than the second—Water Works and Hydraulics—which will thoroughly cover this field, giving not merely articles on design and construction, but on the operation and maintenance of plants. This monthly will be the first of its kind to be published in America, and we plan to make it indispensable.

The designer of "framed structures"—buildings, bridges, and the like—will find the fourth issue, the Building and Structures Monthly, a periodical devoted to his specialty. The type of buildings that will there be discussed and illustrated will be what may be termed engineering buildings—those in which utility predominates over art, such as mill and factory buildings, reinforced concrete, steel and fireproof buildings in general. There are many architectural periodicals, but none covers the "building engineering" field at all satisfactorily. We believe, therefore, that our Building and Structures Monthly will fill a decided want, not perhaps a "long-felt want," for the weekly article service that we and other engineering papers have given, has served. But we believe that it has not served well enough, and that a monthly devoted entirely to "structural engineering" will fill a latent, if not a "long-felt," want so well that a reversion to past practice will become impossible.

Thus far we have spoken about the wants of engineers. The contractor, who may or may not be a graduate engineer, but who in the broad sense is an engineer, usually desires not merely an article service, but a contract news service. This news service he will receive as heretofore, but even better than in the past. Also articles on methods and cost of construction will continue to be a feature of "Engineering and Contracting."

Some contractors, notably those in the railway field, do not require a weekly news service. Our third issue—the Excavation and Railways Monthly—will fully meet the requirements of most railway contractors. When "Engineering and Contracting" absorbed "The Dirt Mover," a few years ago, it gained many readers who specialize in grading work. We have held nearly all of those who are contractors, but we have lost some of the "dirt moving" superintendents and foremen to whom a weekly paper of diversified character evidently does not appeal as strongly as does a monthly magazine devoted to their specialty—"dirt moving." Accordingly those men will now find their needs filled in the third issue of each month (at $1 a year for this monthly).

The editor has just completed a revision of his two books on excavation and, in doing so, has been pleased to note what a great amount of practical "dirt moving" data has been published in "Engineering and Contracting" during the last ten years. Without undue self-approval, perhaps it may be claimed that this paper has greatly excelled every other periodical in the usefulness and in the quantity of its articles on earth and rock excavation. The writing of books on this subject gives an author so comprehensive a view of the literature of "dirt moving" that he can scarcely err in his appraisal of the relative merits of the different periodicals that have published articles on excavation.

The engineer or contractor who wishes a broad civil engineering weekly paper will continue to secure it in "Engineering and Contracting," for, although the new plan effects a concentration of certain classes of articles in certain issues, the aggregate for each month will cover the whole field in the future as in the past.

"Engineering and Contracting" is about to make a radical departure from precedent, but the innovation is one that appeals irresistibly as an advance in the right direction.

TWELVE YEARS' PROGRESS IN ROCK DRILLING.

Some branches of civil engineering work have experienced remarkable changes during the past decade, notably road building. Other branches have changed relatively little. The art of rock excavation falls among the latter. In rewriting a book that was published 12 years ago the editor was struck by the fact that nearly every fact that he had given in the original edition is still pertinent. It is true that many additional facts are now available, but they serve, in the main, either to reinforce conclusions established 12 years ago or to give greater details under a greater variety of conditions than were then available.

The two most important innovations in rock excavation that have occurred during the last generation are the use of the cable drill for deep holes and the pneumatic hammer drill for shallow holes. But each of these types of drill had begun to be used fully thirteen years ago.

The cable drill, originally developed for well drilling, was first used for blast hole drilling in 1913 and its use was first described by the editor who was at that time on the staff of another engineering paper.

To a superintendent who had used well drills the thought occurred that the same type of drill would be economic on railroad grading. His employer, however, could see no merit in a cumbersome well drill for such purpose and would not permit him to experiment. However, when the contractor's back was turned, the superintendent rented a well drill and began using it for drilling blast holes. It was a pronounced success, but the contractor was so exasperated at having his orders disobeyed that he "fired" his inventive superintendent without waiting for excuses. But when he discovered that the well drill had not only greatly reduced the cost per foot of drill hole but had made it possible to space holes farther apart, he sent for the discharged foreman, and, according to unverified rumor, remarked: "The Bible says fools rush in where angels fear to tread, so I guess I needn't be backward in taking off my hat to a man who was a big enough fool to think of using a well driller on a railroad cut. You've struck oil on this job and your salary will be doubled."

Who the man was that thought of using a pneumatic riveter for drilling rock, history fails to mention. Probably its first use was in drilling plug and feather holes. At any rate the editor first saw the "air hammer" used in a Massachusetts granite quarry for that purpose. Subsequently this type of drill began to be used in mining, where it speedily gained popularity and coincidently grew in size.

Another innovation that dates back less than ten years is the "wagon-mounted percussive drill," which consisted of a truck (often self-propelling) carrying a percussive or piston drill mounted so that it can be raised and lowered bodily in "gins" or "leads" (similar to those of a pile driver), mounted on a turntable. Doubtless this design was suggested by the mounting of subaqueous drills in "leads" on scows. Where the rock surface is comparatively level the wagon-mounted drill is apparently destined to grow in popularity. As stated in our issue of May 24 one of these wagon-mounted drills average 200 ft. of hole per 10 hr. day for 2½ years on the Sag Channel of the Chicago Drainage Canal, the holes being 3½ in. diameter and about 12 ft. deep in limestone. Such a remarkable achievement would be impossible with a tripod drill because of the large percentage of time lost in shifting from hole to hole and in the more frequent changing of bits required where the entire drill machine can not be raised and lowered bodily in "leads." In Gillette's "Rock Excavation" the best long-time record of tripod drilling on the Chicago Drainage Canal was 82 ft. of hole per 10 hr. shift, holes being 12 ft. deep and 2 in. diameter at the top. This, it will be noted, is only 40 per cent as much footage (with a smaller hole) as has been averaged in the same rock with wagon-mounted drill above referred to.

The mounting of a drill on trucks of course permits the use of a larger machine, and this, in turn, makes it possible to drill holes of greater diameter and of considerable depth. Holes 4 in. diameter at the bottom and 30 ft. or more deep can thus be drilled economically. With deep holes of large diameter the spacing of the holes can be made greater.

A water jet to keep the bottom of a drill hole clean is not a new device, but it has come more and more to be recognized as a very effective means of increasing the footage drilled in a given time. Still, there are hundreds of contractors and superintendents of rock work who have yet to learn the merit of this simple expedient, particularly as applied to rock that chips off in comparatively large fragments under the blows of the bit. The larger the chips and the bigger the hole the greater must be the volume of water forced into the hole through the jet pipe, in order to lift the chips out of the hole. If the rock chips are not removed as rapidly as they are made, the drill spends much of its time acting as a pestle pulverizing them, instead of breaking off new fragments of rock.

Percussive electric drills and gasoline drills have, as yet, not come into general use. Electricity is readily transmitted at small cost; gasoline makes each drill its own power plant. Yet the difficulties that attend the use of electricity and gasoline in rock drilling are so great that these two sources of energy have been slow of adoption for this purpose.

Rock augers have been successfully used in tunnels and other underground work where the rock was soft. It is not beyond the range of possibility that during the next ten years the auger type of drill will be extensively used in open cut work where shale and other soft rocks are encountered. In the California oil fields the auger type of well drill has grown in popularity. Those who contemplate drilling blast holes with augers will do well to study this type of drill as used in well drilling. It seems to be especially adapted for boring holes of very large diameter, and for that reason its use may prove economic even where the cost per foot of hole is high. Large holes heavily charged with explosives may be spaced far apart, and thus effect a low drilling cost per cubic yard of rock.

In general there has been a growing tendency in open cut work to drill holes of larger diameter. We believe that we have by no means reached the economic limit in large blast holes.

MOTOR TRUCK UN-ECONOMICS.

The writer's first job in contracting work was on railway grading in New England 35 years ago. His outfit was a tin pail and dipper and his task was to fill the pail at a nearby brook and distribute its contents to a group of husky gentlemen with shovels and south of Ireland speech. The immediate construction operations were about as follows: A one-horse, two-wheel vehicle called by the men a c-a-r-r-t was backed up to the pit; several men, aided by the driver, with shovels, cast dirt into the cart until it was filled; the driver smacked his shovel bowl down on top of the load and mounting the "front" drove away; as the load was moving off a pitman endeavored to cast a final shovelful to land midway between the driver's shoulder blades. Visiting a few days ago a road construction contract the writer saw spin up to a stone pile a 3-ton motor truck with power dump and other time-saving equipment. Compared with the old two-wheel cart it was a marvelously powerful tool for useful work. Shifting an admiring gaze to witness the loading the writer saw six men on the stone pile with shovels proceeding to the task of filling the enormous body. There was not time to observe whether the final shovelful was cast jocosely onto the driver's back, but otherwise the loading conformed precisely to the dump-cart practice of the writer's first experience. As he moved on toward another part of the work the contractor's man remarked to him that the truck was not handling enough stone and he guessed "they would have to put some teams on to help."

LEGISLATIVE INVESTIGATING COMMITTEES.

Legislative investigating committees have always been popular in New York state. Just why this is the case we will not attempt to explain, but during a quarter of a century of fairly close acquaintance with New York City public works and politics, the writer has difficulty in recalling any considerable period of time when some investigating committee has not been "sitting" in Manhattan or one of her sister boroughs. Just now, or at least recently, the Thomson committee is probing into the affairs connected with the rapid transit subway work of the Public Service Commission. We confess not having very close knowledge of what this committee is doing or why it is doing it, but one thing that it has done is to attack the chief engineer of the Public Service Commission in a particularly inexcusable manner. To ask this gentleman to lay before the committee the records of his office is one thing; to heckle him on the witness stand by questions as to his reputation as an engineer and particularly bluntly to require him to state what he is doing to earn his salary is a quite different thing. To ask: "What do you do for your salary?" is, as an indignant contemporary says, about as unfair as to require a yes or no answer to, "Have you stopped beating your wife?" The salary in question is $20,000 a year. Apparently the legislative committee feels that this is extravagant pay for the technical and executive head of a work involving the expenditure of $300,000,000. Whatever it may think, however, the committee has no right by insinuation and innuendo to throw doubt on the professional integrity of the recipient of this salary in an attempt to demonstrate its extravagance.

COMMON LABOR SHORTAGE.

Contractors in many sections of the country are meeting with difficulties in securing sufficient common labor for their work. In some of the eastern states the shortage of unskilled workmen for road construction is causing much trouble. One of the State Highway Commissioners of Massachusetts estimates that fully 5,000 Italian laborers formerly employed on highway building for the commonwealth have left the state since last fall. Some of these men returned to Italy but the majority secured jobs in munition and powder plants. The situation is the same in other states. The men that formerly formed the bulk of the contractor's forces have either returned to their native lands or are now securing from manufacturing establishments higher wages than they ever received before. The contractor must compete with the factory that is getting war time prices for its products.

"PIGS IS PIGS AND PAVING IS PAVING."

The above title heads a snappily worded little circular sent out by the American Society of Municipal Improvements in connection with its "standard unit" cards intended to encourage definite and comparable pavement cost reports. Any editor of an engineering journal, and indeed anyone at all, who has collected "statistics" of pavement costs must have an appreciative bosom for the mild satire in this title. To many if not to most of those who fill out blanks giving pavement costs "paving is paving." The article on another page discussing comparable pavement costs is commended to our readers.

NOTICE.

Announcement of the awards in our short article contest for bonus payments is at the request of the judges postponed until June 14. The number of articles arriving late, together with the double holiday of last week, prevented full reading and comparison in time for announcement in this issue. The competition will be repeated for the month of June, as will be formally announced in our issue of June 14.

EDITORIAL PARAGRAPHS.

Nine electric locomotives have taken the place of 24 steam locomotives on the electrified division of the St. Paul system. This foretaste of the long predicted displacement of the steam engine by the electric motor is seasoned with many economic spices. On down grades the electric motors act as dynamos and pump power back into the transmission line. Brake shoes are no longer worn out rapidly, and incidental to the main economy come many other savings.

"The undertaking is backed by New York financiers and is managed by a civil engineer who is also a scientific farmer." We quote from a magazine article relating to the farming of 11,000 acres of land (2 by 9 miles) recently reclaimed by drainage in Western New York. "A cost system is maintained and it is possible to know just what each crop costs." May not the slump in railway construction that has been so pronounced during the last few years prove eventually to have been a good thing for many civil engineers? Throw a real engineer out of a good job and he will often create a better one for himself.

The man who "rifled" the pipe through which heavy crude oil is pumped solved a difficult problem, for, by mixing a little water with the oil, the centrifugal action produced by the "rifling" keeps the water in contact with the pipe and the oil then does not adhere to the pipe. There are conditions where rotary motion of liquids in pipes is objectionable. For example in pumping water containing granular matter (e. g. hydraulic dredging), rotary motion throws abrading particles against the pipe. Might it not be wise in such cases to use pipe of rectangular cross-section? A funnel of that section will discharge a liquid more rapidly than one of circular section.

The rust-proofing of iron and steel remains one of the greatest economic problems, in spite of the numberless efforts to solve it. The purer an iron the more non-corrossive it is, but at the sacrifice of strength. Painting lasts but a few years at best. Enameling is prohibitive, for most purposes, on account of the first cost, to say nothing of its tendency to crack off under blows. An Italian chemist claims to have solved the problem by giving iron or steel a protective coating of oxide. The metal is heated in a muffle into which superheated steam is turned. The fumes of a powdered chemical (of unstated composition) are then blown upon the metal, producing an iron oxide that adheres permanently.

The reports on cities of the Committee on Fire Prevention of the National Board of Fire Underwriters contain about the best general descriptions of which we know of the water supply systems of those cities. Engineers having occasion for such information should keep in mind this source.

Peace rumors and war orders seem to be closely connected. A few days ago the newspapers devoted considerable space to reports that the end of the European holacust was in sight. The nexy day the U. S. Steel Corporation received the largest single contract for shell forgings thus far placed by the British Government. Possibly the warring nations have not been notified that peace is at hand.

DEVICE WANTED FOR MECHANICAL CLEANING OF 5½x6 FT. BRICK AQUEDUCT.

To the Editors: We are seeking information concerning some system for cleaning the inside of a brick water supply conduit about 5 ft. 6 in. by 6 ft. in cross section and 4½ miles long. The substance to be removed consists of silt, mixed with more or less slimy vegetable matter which is easily removed by a brush.

If possible, we would like to obtain some apparatus whereby a set of revolving brushes mounted on a small self-propelled car can be run through the conduit and thus do away with the use of the large crew of men necessary for hand cleaning.

If your readers know of any place where such a scheme has been worked out or applied, we would appreciate it if they would let us know the name and address of the organization.

Yours very truly,
Roscoe L. Smith, Prin. Asst. Engineer.
St. Paul, Minn., May 26, 1916.

HISTORY AND ENGINEERING DESCRIPTION OF THE LOS ANGELES AQUEDUCT.

During the past decade Engineering and Contracting has published at intervals articles dealing with various phases of the construction of the Los Angeles aqueduct, which comprises a system of water works carrying a flow of 260,000,000 gal. daily from the Sierra Nevadas, across the Mojave Desert and under the Sierra Madre range, to the city's gates.

From the following letter we are informed that the city of Los Angeles has now on the eve of publication the final report of this great hydraulic work, and we give publication of the communication from the interest it will undoubtedly have for our readers.

To the Editors: After nearly two years of preparation the Los Angeles Department of Public Service will shortly publish the final report of the construction of the Los Angeles aqueduct. The magnitude of this enterprise, the many engineering problems encountered and its completion within the time and money estimates with the labor forces under city engineers is too well known to call for any description here of the scope of the work. It will be sufficient to state that the report will comprise a volume of approximately 350 pages, stoutly bound in library binding with over 100,000 words of text, 86 full page and half page illustrations and 45 pages of line drawings.

In addition to a short history of the whole enterprise dating from inception to completion, the volume in clear and concise language enters upon a technical description of the construction, including the laying of steel siphons 6 ft. 8 in. to 11 ft. in diameter, 11 ft. concrete inverted siphons, transportation, organization, cost keeping, bonus payments, with concrete illustrations for various phases of the work, steam shovel excavation, concrete flumes and conduit lining, co-efficients of flow, tufa cement manufacture, original studies of water development, study of the aqueduct from the standpoint of a sanitary supply, etc., etc. Cost data are found at frequent intervals throughout the book, which is, in short, almost a treatise on hydraulic engineering.

The volume cannot be distributed gratuitously. The cost of printing alone would prevent this, but the board recognizes that to engineers, contractors and those engaged in engineering work, this volume will be a desirable acquisition, and to that end it has placed the price at which it may be obtained at $1.95 per volume postpaid. This amount does not cover the cost of printing. The board in no way profits by the sale or distribution of the report and has no other interest than that of placing it in the possession of those who will use and appreciate it. It will be sold entirely by subscription and the only requirement is that the orders, accompanied by remittance, shall be received within the two weeks after this appears, as only the number of copies will be printed for which orders have been received. Remittances should be made payable to the Los Angeles Department of Public Service, 645 South Olive street, Los Angeles, Cal.

Thanking you for any publicity to which you may deem the above entitled,

Very truly yours,
R. F. Del Valle, President.

QUARRYING AT ROCKLAND LAKE.

Contributed by H. L. Hicks, New York City.

One of the largest trap-rock quarries in the East is the Rockland Lake Quarry on the west bank of the Hudson River, at Congers, N. Y. Many improvements in plant and method of quarrying have been instituted here recently and the New York Trap Rock Co., who operate this property, are beginning their second season with an enlarged crusher plant and steam shovel loading equipment which has increased their output of crushed rock a third and has reduced the loading force to one-tenth of what it was.

Quarrying operations which have been carried on here for 30 years have "carved a slice out of the mountain" until the present working face is 540 ft. high at the center portion and about 3,000 ft. in length. The quarry floor is 60 ft. above the river and about 400 ft. wide. The working day is limited by the light and is, at this season from 6:30 a. m. to 5 p. m. The working force totals about 150 men, 30 of whom are engaged in loading rock at the quarry face. The daily output is about 4,000 cu. yd., an increase of 1,000 cu. yd. over last year's production. The crushed rock is loaded into the company's scows and delivered at any tidewater point.

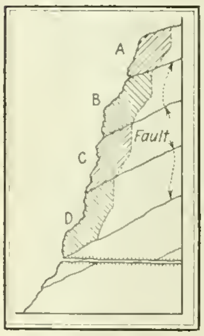


Fig. 7—Diagram of Quarry Face.

The rock formation is a very hard, blue traprock, seamy and broken. A series of outward sloping cleavage planes, or as the quarrymen call them "faults," greatly facilitate the breaking off of large masses of rock, with a minimum amount of drilling and blasting. In quarrying, the working face is kept as nearly vertical as possible (Fig. 1), so that the rock will fall at the foot of the cliff, without scattering.

While it would seem that the drilling of blast holes on this precipitous quarry face would be an ideal job for a light weight Jackhamer drill, it has been found that to take full advantage of the natural cleavages in the rock structure, deep holes and heavier blasting charges are needed. This brings into use reciprocating piston drills, of which there are five at work.

There is very little earth overburden at the top of the cliff and in many places the rock is exposed. To remove the upper layer of rock a row of 10 vertical holes about 30 feet apart is drilled 25 feet back from the face. These holes are 18 to 20 feet deep and are loaded with black powder and shot simultaneously. This blast causes a break to extend downward to the first cleavage plane. The force of the explosion tends to throw out the large mass of rock "A" (Fig. 7), while the slope of the natural cleavage line permits it to slide off easily and fall to the bottom of the cliff. The second step in working downward is the drilling of holes on the ledge of the "fault." The face of the quarry becomes very irregular and, therefore, it is impracticable to drill these holes in rows. Two or three holes are put in wherever the most rock can be gotten out with the least powder. These odd groups of holes are of about the same depth as the first row and in blasting break to a second "fault." This method is repeated, bringing down successively "B," "C," etc., until the bottom is reached.

On drilling on the ledges it is usually necessary to drive a couple of pegs and fix a plank to hold the drilling machine, steels, etc. The holes for these pegs are often drilled with Jackhamers, as a man can easily handle one of these drills on a very scanty footing. In starting such holes the drill runner descends from the top, taking particular pains to dislodge any fragments of rock which might become loosened while he is at work below.

The deep blast holes are started with 3¼-in. bits and bottom at 1¾ inches—10 changes of steel. Cross bits are used for all this work. The drilling machines and steels are hoisted from the quarry floor up one of several inclined ropeways and lowered or swung into position. This hoisting is done by horses—or by one of the "dinkies" when it is handy.

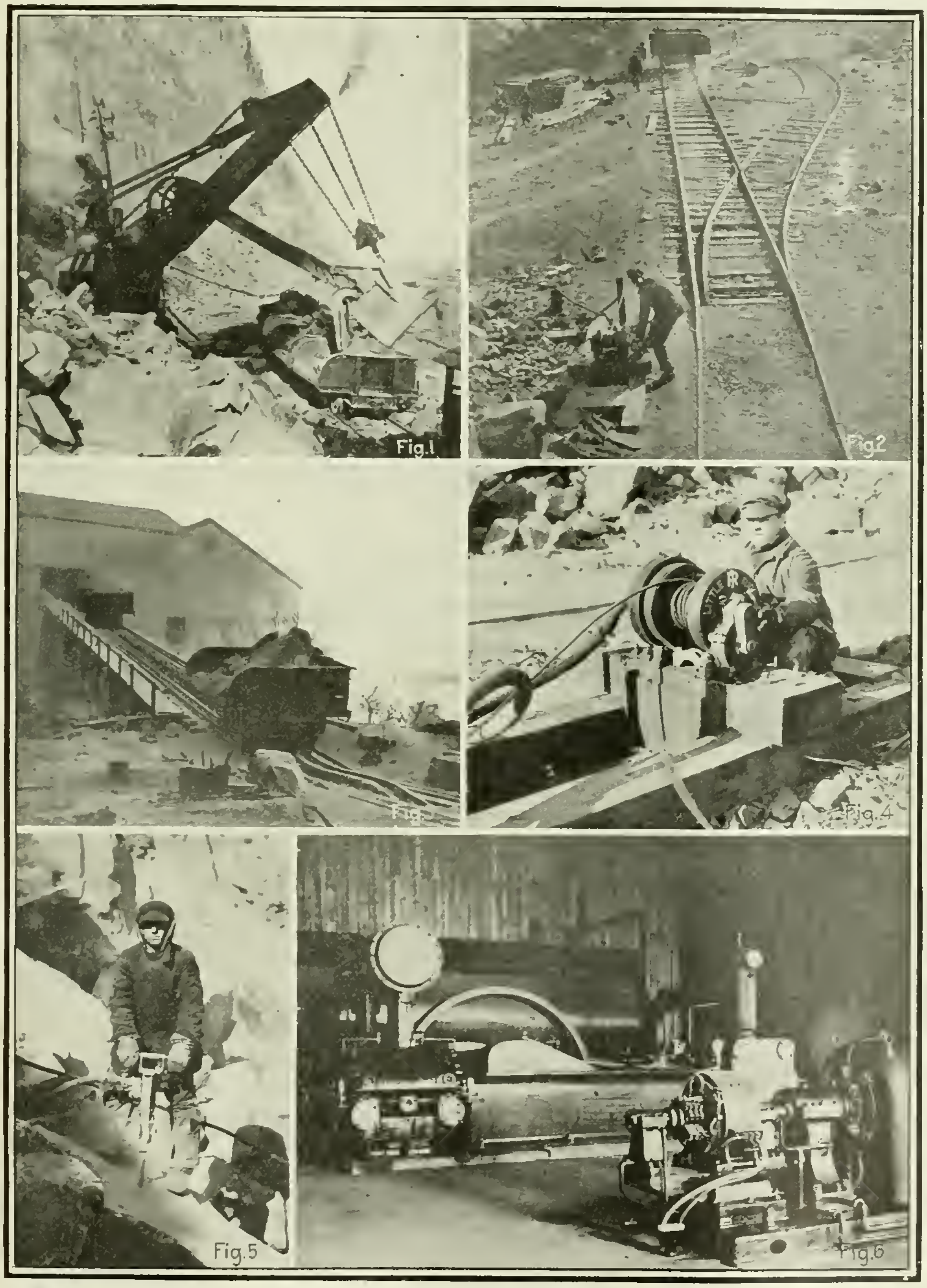


Fig. 1—The Precipitous Profile of the Rockland Lake Quarry. Fig. 2—Little Tugger Hauling Cars Up-grade to Switch. Fig. 3—Loaded Cars Entering Crusher House. Fig. 4—The Little Tugger Starting a Haul of Two Cars. Fig. 5—Blockholing With a Jackhamer. Fig. 6—Imperial Air Compressor at the Lower Power House.

The drilled blast holes are sprung or "squibbed" with about 25 pounds of dynamite, both to enlarge the cavity for the powder charge and to start lateral cracks into which the powder can be worked, so as to spread the blasting force. "Squibbing" is often repeated when the first charge does not develop a decided cleavage crack. Under favorable conditions and with careful spreading of the powder the rock will break from 15 to 20 feet either side of the drill holes. The black powder blasting charge varies with the character of the rock, 300 pounds being considered a heavy charge for a difficult break.

The rock shatters well in falling, but block-holing of the larger "chunks" is necessary. This work keeps seven Jackhamers (Fig. 5), busy, putting in holes averaging 2 feet deep, although at times steels up to 7 feet are needed.

For this work the drill bits used are of the "Carr" type, this having been tested and proved to be, in this hard rock, about 50 per cent faster than the 6 point rose bit formerly used. The Jackhamers average from 100 to 200 holes per day. The holes are loaded with 60 per cent Du Pont dynamite and fired with fuses. The cost of dynamite for block-holing is now less than $.001 per yard of total output.

Shooting of both blast holes and block-holes is done at noon and night—preferably night—although a few blockholes are often shot at odd times to prevent delay in loading.

The loading equipment consists of two Bucyrus 110C (4 yard) steam shovels leading into open side steel cars. These shovels are said to be the most powerful machines at work in this part of the country.

There are 30 cars, handled in strings of 5 by three "dinky" locomotives.

Loaded cars are delivered by the locomotives to an inclined cableway where they are hauled up into the crusher house (Fig. 3), and dumped directly into the crusher. From here they coast down an incline and up a slight grade toward the upper end of the quarry, where they are switched over and run by gravity, back parallel with the quarry face. It frequently happens that a car or two cars will not carry past the switch, and to keep the cars in motion a Little Tugger (Ingersoll-Rand), has been bolted to a timber at the extreme end of the track (Fig. 2). This hoist is of the small air operated type originally developed for winze hoisting in mines. When needed this machine hauls two 6½-ton cars up this 6 per cent grade without any trouble. Fig. 4 shows the remarkably compact construction of this machine. Its weight is only 185 pounds.

The crushing equipment consists of a large 72-in. by 84-in. Taylor Jaw Crusher, 2 8-in. and 8 6-in. Gates Gyratory Crushers and a 72-in. Traylor Roll. These deliver the crushed rock directly to the bins, from which the scows are loaded.

The drill sharpening and blacksmith work is divided between two men. One sharpens the piston drill steels and does the general work and the other operates a No. 5 Leyner Drill Sharpener. This machine is used for forging bits and shanks and resharpening the Jackhamer steels.

The power equipment at the Rockland Lake Quarry is divided between two power houses, the one being a part of the crusher plant and the other a new building at the lower end of the quarry. In the first are installed 4 16-ft. by 72-in. tubular boilers, a 28 by 48 Wright engine, a low pressure Allis-Chalmers turbo-generator, a turbo lighting set, a Wheeler surface condenser and the necessary auxiliaries. Here is also a small air compressor which is held for emergency use. The low pressure turbo-generator is operating on exhaust steam at 1 pound pressure, which the master mechanic says "is as good as finding the power."

The lower power house contains the main air compressing unit, a 24-in. stroke Imperial Corliss steam driven machine (Fig. 6), of 2,400 cu. ft. capacity, a Westinghouse high pressure turbo-generator, surface condenser and auxiliaries. The boiler equipment consists of 4 18-ft. by 72-in. tubular boilers, an open type feed water heater and a Cameron boiler feed pump. The exhaust steam from the compressor is used to heat the feed water.

The turbo-generators in both power houses may be synchronized to carry the load together or either may be operated independently.

The Imperial (Ingersoll-Rand) compressor has as an air receiver, a horizontal boiler, placed directly outside the building. From this an 8-in. air line leads to the quarry floor, where two 6-in. branches extend in either direction along the quarry. These air lines are buried to prevent damage from flying rock and are provided with branch connections at intervals. Air is carried along the top of the quarry by a 2-in. air line. A pressure of 80 pounds is maintained at the drills. In cold weather the air is reheated in a crude manner, log fires being maintained under the branch air piping near the point of use.

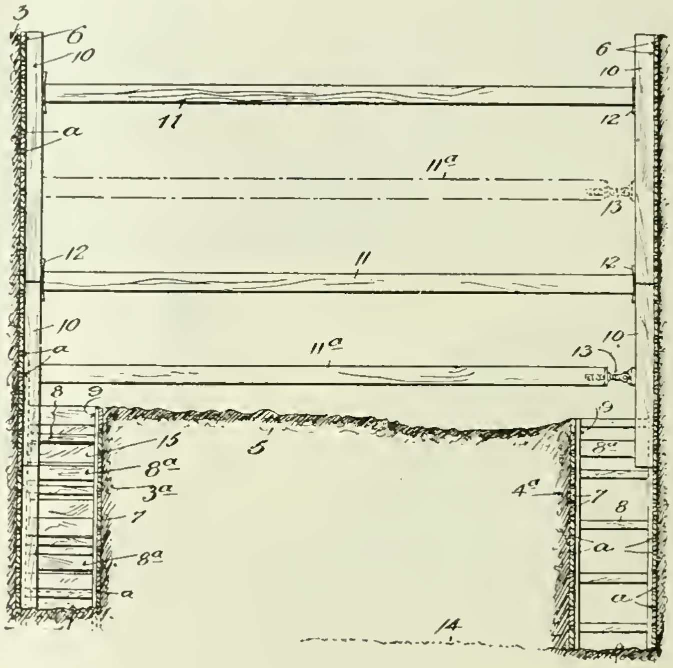
Water for the boiler plants, the shovels and locomotives is pumped by an air lift from a 160-ft. well. This supply is maintained with practically no attention and, with air already available, at low cost. For condensing purposes the slightly salt river water is used.

The pumping of water is only one of the extra uses to which air is being put; the blacksmith uses it for blowing his forge, the Little Tugger hauls cars on air power, and the workmen who are building a scow (on contract), use air for operating pneumatic wood borers and a hoisting engine. This latter is a steam hoisting engine which, with intermittent operation totaling at most an hour of continuous use per day, has been found to operate more economically with air than when burning coal.

A METHOD OF EXCAVATING DEEP CUTS TO NEAT LINES.

A method of excavating deep cuts with vertical sides which has been used successfully on rapid transit subway construction in Fulton St., in Brooklyn Borough, New York City, has been patented by John F. O'Rourke, one of the firm of contractors doing the work. The general method is illustrated by Fig. 1 and is explained as follows in the patent specifications:

Referring to this figure, at the place where an excavation in the ground is to be made, two trenches 1, 2, are dug of suitable width and narrower than the proposed excavation, to a suitable depth, and spaced apart in such a manner that the outer walls 3, 4, of such trenches may be spaced approximately the distance of the width of the proposed excavation, leaving between the trenches temporarily unexcavated ground at 5. As said trenches are dug, their walls or sides are braced or shored, preferably with longitudinally extending planks 6, 7, the planks 6 being shown applied along the out walls or sides 3, 4, of the trenches, and the planks 7 applied along the inner walls or sides 3a, 4a of the corresponding trench, temporary braces 8 being placed between opposed planks 6, 7, in the respective trenches. Such temporary braces 8 are preferably placed against vertical boards or the like 9 that are laid against the planks or shoring 6, 7. After the trenches have proceeded to a suitable depth, vertical rangers or timbers 10 are placed against the outer walls of the trenches, in position between the previous bracing 8, 9, of the trench walls, and said rangers 10 are themselves braced and wedged against the inner walls of the corresponding trenches, by means of suitable braces 8a extending between the rangers 10 and vertical boards that are placed against the planks 7, whereby the first named bracing 8, 9, may be removed in whole or in part as may be desired. The vertical rangers or timbers 10 will thereupon temporarily remain braced against the inner walls 3a, 4a of the trenches, the planks 7 then remaining in place by reason of the unexcavated material between the trenches. After the upper rangers 10 have been placed as stated a suitable amount of the intermediate ground 5 is first excavated to admit cross braces or timbers 11 of sufficient length and strength to be inserted between the upper parts of opposing rangers or timber 10, and the work of continuing the excavation at 5 proceeds until space for another cross timber 11 is made. When such brace is placed and wedged the side trenches are continued with the same operations of bracing, etc., corresponding planks 7 being removed as the excavation at 5 proceeds. When the trenches have been dug downwardly sufficiently to admit additional vertical rangers 10 the latter are placed beneath, or they may be joined to, the first set of rangers above, in convenient lengths, and against the outer walls 3, 4, and the horizontal braces or beams 11 may be placed to oppose the bottom of one ranger 10 and the top of another, or if desired a timber bolster A may be placed at the joint between said rangers 10 to distribute more securely the thrust of the cross braces 11 on the rangers above and below. The lower portions of the rangers 10 set in place as last referred to, may be temporarily braced against the inner walls 3a, 4a by the braces 8a, 9a as before described, the excavation 5 being continued a suitable depth, and, where desired, temporary braces 11a and wedges or screw jacks 13 may be inserted between opposing rangers or timbers 10, until the excavation has proceeded downwardly sufficiently to admit the more permanent braces 11 between opposing rangers. It thus will be understood that as the work proceeds, the opposing walls of the trenches are not only first and temporarily braced by the bracing means 8, 9, but are secondarily braced by the bracing 10, 8a, 9a, and then by the more permanent bracing 10, 11, whereby the weight of the material on the outside of the excavation above the trenches is taken up by the cross timbers 11, which may remain permanently in position while the work is being carried on. Wedges indicated at 12 may be driven between the parts 10, 11 to make firm bracing. It will be observed that the outer planks 6, opposing the timbers 10, remain in place as the work proceeds, although the planks 7 are removed successively. The work may proceed stage by stage until the trenches have reached the desired low level, and the completed excavation of the desired width and to the desired depth has been accomplished, as, for instance, to the level indicated at 14.



Typical Section Showing Improved Method of Excavating Deep Cuts With Vertical Sides.

NOVEL HYDRAULIC-FILL TEMPORARY DIVERSION DAM CONSTRUCTION, COLORADO RIVER.

The dam described was constructed in 1915 to divert water into the Imperial irrigation canal. It was a temporary expedient made necessary by very low water in the Colorado River in conjunction with a heavy demand for irrigation water. The work as described by J. C. Allison, Proceedings American Society of Civil Engineers, Vol. XLII, p. 682, was as follows:

The Colorado—like other rivers forming deltas—scours and refills its channel bed with the increase and decrease of quantities of water, and a direct relation exists between the character of the materials forming the bed and the velocities of the water. For example: The river bed is scoured to an elevation of 85 at Yuma, Ariz., by a discharge of 140,800 sec.-ft., whereas it is refilled to an elevation of about 110 by a discharge of 3,400 sec.-ft. The only reason that the bed does not scour deeper than an elevation of 85, with a discharge of 140,800 sec.-ft., is that at that depth the materials constituting the bottom are so heavy that the velocities, registered as 6.8 ft. per second for this discharge, will not move them. It follows that, in refilling the bed, the materials are graded as to weight, and deposited in direct relation to the velocities. It also follows that the refill in all cases is in strata of materials decreasing in weight as they approach the elevation corresponding with the lesser velocities.

The scour line of the bed of the Colorado at the dam site is at an elevation of about 84. The ladder of the 10-in. suction dredge El Centro, operating in the river was designed so as to make it possible to pump from an elevation of 80 when the surface of the river was 110. The materials in this area below the scour line had withstood the scouring effects of velocities as high as 7 and 8 ft. per sec. Those materials, when brought to the surface and deposited in the water where the velocity had decreased to 2 and 3 ft. per sec., due to falling discharge, were certain to stand in the position placed by the discharge of the dredge, making it possible to construct a hydraulic fill dam under water of a running stream varying in depth from 2 to 15 ft.

The dam was constructed from Aug. 12 to Sept. 12 and the cost of the work was as follows:

40,000 cu. yd. of sand and gravel fill, at 2.7 ct. per yd.	$1,080.00
21,300 burlap and canvas sacks, at 3 to 6½ ct. each	1,140.00
450 cords of willow brush and poles, at 73 ct. per cord	328.50
800 lb. of wire	32.00
Cables and clamps	100.00
Labor, filling and placing sacks, carrying and placing brush, poles, etc.	2,000.00
	$4,680.50
Plus 10 per cent for superintendence and tools, etc	468.05
Total	$5,148.55

Since Sept. 12 there has been an additional expense of $2,000 for raising and strengthening the dam by dredging, and for labor in closing and opening the dam, and general maintenance of the structure, making the total final cost $7,148.55.

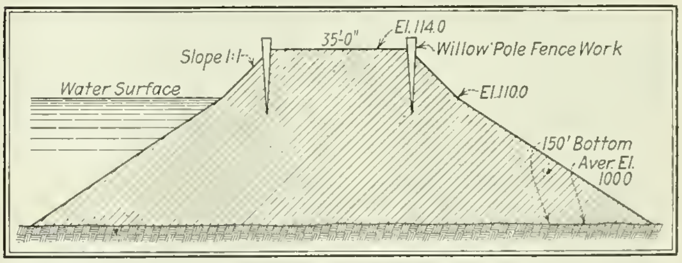
Construction Methods.—Pumping was commenced on the Arizona side, the dredge pontoon being some distance above the site of the dam, and the discharge being carried astern through a 10-in. pipe floated on pontoons to the fill. Owing to the admixture of lighter grades of material encountered in burying the suction pipe to the scour line depth, and to the subsequent caving in on the suction of the surface materials when the depth was once reached, the base of the dam, in a great many places, became as wide as 150 ft. The heaviest materials pumped—in some instances stones and cemented adobe chunks 6 in. in diameter—remained exactly where placed, but the lighter sands and gravel were carried by the current some distance down stream before they lodged in permanent position. When a point near the water surface was reached with the fill, the conservation of the material was made possible by constructing brush fences to help retain the material at the slope required. (Fig. 1). By this process the structure was carried across the stream to the point of final closure. Three re-runs across were made later with the dredge, bringing the crown to an elevation of 114, which is about 5 ft. above the water surface of the river when 5,000 sec.-ft. are passing into the canal.

On Sept. 10th, 2,300 sec.-ft. were passing through the opening in the dam, and 3,300 sec.-ft. had been diverted into the Imperial Canal. The head on the dam was 2 ft., and the resulting velocity through the remaining opening was 8 ft. per sec. The bottom of the opening had been paved with about 10,000 sacks, filled with gravel pumped by the dredge, and stoutly tied, decreasing the depth to about 5 ft., and thereby preventing scour. Great quantities of sacks were used in protecting the Arizona end of the opening, the California shore, as before stated, being protected by its rock facing. Additional sacks were used in forming the overpour riffles as fast as the head developed. A great number of the sacks were of no avail, either because of their lodgment in the wrong place, or because of breaking and washing out; and, throughout the whole process, constant replacements were required because of the boring effects at the toe of the sack riffles, causing the embedding of the sacks.

In paving the bottom, the point above the opening at which the sacks should be dropped in order that they might lodge on the bottom in the proper place, was determined by constantly experimenting with sacks thrown overboard attached to wires, thus making it possible to locate the sack when it had finally settled by following the line of the wire. Only those filled with the coarsest shingle and gravel and of greatest weight would remain in position and withstand the velocity for any length of time.

In the final closure, when the bottom had been protected carefully, cables were stretched across, securely anchored to deadmen on the California side and in the body of the dam on the Arizona side. The first cables used were of ¾-in. plow steel, but proved to be too light when maximum strains were put on them. After one failure in making the closure, due to breaking the cable, a double strand of 1¼-in. cable was used for the lower run.

Willow poles were cut from the shores near by. The poles were 30 ft. long, the diameter of the large end being 10 in., and the small end tapering to 5 or 6 in. By the skillful use of barges and lines working above the openings, these poles were maneuvered with the current in such a manner as to cause their large ends to lodge against the cable stretched across the opening above the water surface, while the small ends rested on the bottom at an angle of 30°, much as a drifting snag will lodge in a swiftly running stream when the heavy end is dragging the bottom and the upper end encounters a surface obstruction of trees or other large drift. These poles were placed against the cable, in this manner, with enough space (sometimes 4 or 6 in. between them) to give sufficient strength to the structure and yet not decrease the area in the opening so greatly as to produce much additional head. When all the poles were in place, large bundles of willow brush were made up, weighted heavily with sacks, and rolled into the water from the barges, anchored some distance above the opening, in such manner as to cause them to strike the bottom of the channel and roll against the lower ends of the poles. As additional bundles were thrown in, the pressure against the poles increased, forcing them to bend, until in some instances, before final relief to the strain was obtained, the upper parts of the poles were standing vertically, and the lower sections were bowed to the extreme. Green poles were always chosen because of their flexibility.



Colorado River Hydraulic Fill Dam.

The placing of the bundles of brush was carried on in sections only, and only in sufficient quantity to decrease the velocity through the section to a point where material deposited by the dredge could be retained in place. In this manner the strain against the poles in any section of the opening was of short duration, as the dredge would give relief in a few hours by extending the dam above. Of course, a great many sections failed during the work, because of poles breaking, but means were at hand for speedy replacement when such accidents occurred. Because the impounded area above the dam was so great as to require several hours to increase its elevation when flow through the opening was reduced, the extra heads created by stoppage with the brush were not felt on the poles to any great extent before the dredge had given relief.

CAMPING INSTRUCTIONS AND OUTFIT REQUIRED FOR CONSTRUCTION CREWS.

Contributed by Walter H. Meier, Oklahoma City, Okla.

These instructions are for the guidance of the construction foreman in setting up, operating, taking down, moving and returning to stock, a camp outfit where its use is required on construction work, and for the guidance of the camp cook in the handling, operation and general welfare of the equipment furnished.

Responsibilities.—The foreman is reponsible for the receiving, checking and reporting of all items of the equipment, etc., furnished with the camp outfit. He is responsible for the proper setting up and operation of the camp and equipment. He is further charged with the responsibility of providing the right quantity and quality of groceries and supplies and with seeing that the cook uses such in a proper and economical manner and that sufficient quantity of food is prepared that each employe may have all that he desires.

The cook, under the supervision of the foreman, will be responsible for the general sanitary condition of the camp, for the economical and proper preparation of the food and with the furnishing of the foreman from time to time, with a list of groceries and supplies needed.

Instructions.—The foreman and camp cook must thoroughly familiarize themselves with every detail of these instructions and follow them closely in order to obtain the best results. If in the actual handling of the camp any changes or additions are suggested that will make a justifiable improvement, a recommendation to that effect should be submitted.

Receiving and Checking Equipment.—In receiving and unpacking the camp equipment, special attention must be given by the foreman and the camp cook to the method of packing the equipment so that this same plan may be followed in packing and returning the equipment. A complete list shall be made of the equipment and this list checked with the list furnished in these instructions and notation made of any shortage or difference in case any articles are found missing.

Packing and Returning Equipment.—Upon the completion of the work upon which the camp outfit is used, the supervisor of supplies shall be consulted regarding the disposition of the equipment. After serving the last meal on the job, every article of equipment shall be thoroughly cleaned; each packing box thoroughly cleaned and the articles packed carefully in the boxes, placing each article in that particular box in which it belongs as shown on the list of standard articles. Each tent and piece of bedding shall be thoroughly aired and dried before being packed, but in case it is not possible thoroughly to dry each article, the supervisor of supplies must be called for instructions. A complete check of the camp equipment shall be made and checked with the standard list contained herein and a notation made accounting for any shortages or differences.

Groceries and Supplies.—As far as practical all groceries and supplies for the camp shall be ordered through the supervisor of supplies so that he can arrange for the furnishing of such groceries and supplies from wholesale houses, thereby making a large saving in cost. Certain articles of groceries and supplies cannot be furnished through the wholesale houses on account of the small quantity needed, but in these cases the supervisor of supplies will furnish the foreman with authority to make local purchases. There will be other items of supplies such as fresh vegetables, butter, milk, chickens, etc., that will be economical to purchase from the farmers, but even in these cases, blanket authority for the local purchase shall be secured from the supervisor of supplies. The list of groceries and supplies attached to these instructions, should be used by the cook as a guide in preparing list of supplies needed. Special attention must be given both the cook and foreman in the ordering of supplies toward the close of the job so that a very small quantity, if any, will be left upon the completion of the job.

It is the company's desire that each employe be furnished each meal with as much good and substantial food as he requires, prepared in a proper way. The bill of fare shall give constant variety and special attention given not to serve one article continuously until the employes tire of it. The foreman should pay particlar attention to these features and should provide himself with a camp cook who will follow this plan in a good and economical manner.

Setting Up Camp.—The foreman shall select a suitable site for the camp, paying particular attention to a clean, dry and healthy location, reasonably close to good water. The camp should be located, as far as practicable, so that it will not be necessary to travel great distances to the work or to move camp too frequently.

In setting up camp the first time, the foreman shall personally supervise the work, following out the plan outlined on the attached blue prints. The order in which the tents shall be erected is as follows: Kitchen tent; Dining tent; Tent fly awning between kitchen and dining tent; Commissary and foreman's tent; Sleeping tents.

Immediately upon the erection of the kitchen tent and commissary tents and before the sleeping tents are erected, the groceries and supplies shall be placed in proper order in the commissary tent, after which the camp range shall be set up and the packing boxes placed in their proper position; then the different tables shall be made and set up. This order of setting up the camp shall be followed so that the first meal may be started as soon as possible, as the sleeping tents can be erected while the cook is preparing the meal.

The foreman shall thoroughly instruct the camp cook in the setting up of the first camp so that subsequent set ups of the camp may be handled by the camp cook without the personal supervision of the foreman.

Moving Camp.—Preparatory to moving the location of the camp, the foreman shall select a suitable site for the new camp. If the foreman's work can be so arranged it is desirable that he personally supervise the moving of the camp, but otherwise the moving of camp should be under the supervision of the camp cook, men being provided for this purpose by the foreman; generally two will be sufficient.

The taking down of the camp and the setting up in the new location shall follow in the same order as that given above for setting up the first camp; that is, the kitchen, dining and commissary tent, with supplies and equipment, shall be first taken down and the first set up in the new location.

Sanitation.—The general sanitation of the camp is of the utmost importance and the foreman shall pay particular attention to this feature and see that the camp cook and cook's helper do everything in their power to maintain a high standard of cleanliness.

All garbage, table scraps, empty cans, etc., shall be placed in a garbage barrel fitted with tight cover and shall be hauled off by the construction team to some distant place from the camp or buried at least once a day.

Wash water shall not be thrown indiscriminately around camp, but instead a small drain trench should be dug to a distance from the wash bench and instructions given to all employes that wash water must be thrown into this trench.

The floors of the kitchen and dining room tents shall be swept after each meal.

All tables shall be thoroughly cleaned and scoured with soap and hot water after each meal.

Between meals the dishes shall be placed in their proper positions on the tables and each table covered with a tablecover of mosquito bar or cheese cloth.

The dish and wiping cloths shall be washed and boiled in soap and water after each meal and well dried.

A sufficient quantity of clean face towels shall be placed on a rack near the wash bench just before each meal. All dirty face towels shall be thoroughly washed, boiled and dried once a day.

The cook range shall be thoroughly cleaned after each meal and wiped all over with a cloth saturated in grease at least twice a week. The stove shall be thoroughly cleaned in the fire box, on the top and back of the oven, by sweeping or scraping out all soot and ashes.

The coffee pot shall be thoroughly cleaned and scoured inside every other day with sapolio or wood ashes and afterward boiling out with baking soda and water.

The cake griddles shall be thoroughly cleaned each time after their use and the inside well greased. The inside should not be scraped with a knife or sharp instrument.

All other cooking utensils, in addition to being thoroughly cleaned and washed after each meal, shall be scoured with sapolio or wood ashes every other day.

All groceries and supplies shall be kept in the packing boxes in such a way that no dirt and dust can get on them. All fresh meat, butter, eggs, etc., shall be kept in the ice box during summer months.

Personal cleanlinees of the camp cook and cook's helper is of utmost importance and at the time of serving each meal each shall provide himself with a clean apron.

The bedding and the inside of all the sleeping tents shall be aired thoroughly and sunned at least every other day if the weather permits.

A. Sleeping Tents.—These to be of a standard type known as the "Sibley" tent and are to be made of 12-oz. double filling duck, 16 ft. in diameter, 11 ft. in height with walls 2¼ ft. in height. In addition to the regular eyelets and guy ropes at the top of the wall and loops for staking down the walls, each tent is to be provided with guy loops and guy ropes attached near the apex of the tent so that the top of the tent may be guyed in four directions. To be provided with an opening at the apex of the tent for a vent and equipped with an adjustable hood to which are attached three guy ropes. All guy ropes to be equipped with adjusters. Long, heavy oak tent stakes to be provided for all guy ropes and short, heavy oak stakes to be provided for staking down the walls. Each tent to be equipped with a section pole consisting of two pieces of 1½-in. black iron pipe, 5¾ ft. long, each piece of pipe threaded on one end and equipped with coupling; one piece of pipe to be threaded on the other end and fitted with a cuff and spike for the top of the tent. Each piece of pipe to have a ⅛-in. hole drilled through it about 6 in. from each end so that the piece of pipe may be wired together for shipment.

B. Dining Tent.—To be of a size, 16 ft. x 18 ft., top to consist of special waterproof extra heavy khaki with 10-oz. double-filling duck walls; the walls to be 5 ft. in height, each seam and the ridge to be roped. Each guy rope to be equipped with adjusters. Long, heavy oak stakes provided for all guys and short, heavy oak stakes for staking down walls. The ridge pole to consist of three pieces of 1½-in. black iron pipe, 6 ft. in length, each end threaded and equipped with couplings, two pieces to be bored on one end each for the spikes of the uprights. The uprights to consist of two pieces each of 1½-in. black iron pipe 5 ft. in length, threaded on each end and equipped with couplings; one end of one piece of each upright to be fitted with cuff and spike; each piece of pipe to have a hole ⅛ in. drilled through it about 6 in. from each end, so that they can be wired together for shipment.

C. Kitchen Tent.—To be of a size 12x14 ft., top to consist of special waterproof extra heavy khaki, with 10-oz. double-filling duck walls; the walls to be 5 ft. in height; each seam and ridge to be roped; each guy rope to be equipped with adjusters; long, heavy oak stakes provided for all guys and short, heavy oak stakes for staking down walls. The ridge pole to consist of two pieces of 1½-in. black iron pipe, 7 ft. long, each end threaded and equipped with couplings; two pieces to be bored on one end each for the spike of the uprights; the two uprights to consist of two pieces of 1½-in. black iron pipe 5 ft. in length threaded on each end and equipped with couplings; one end of one piece of each upright to be fitted with cuff and spike; each piece of pipe to have a hole ⅛ in. drilled through it about 6 in. from the end, so that they can be wired together for shipment; to be equipped with safety stovepipe hole located in the northwest corner of the tent 24 in. from the north end and 20 in. from the west side; that is, when the tent is set up with length north and south.

D. Tent Fly.—To be of a size 12x12 ft., made of 10-oz. double-filling duck.

E. Stockman's Bed Sheets.—These are to be made of 18-oz. duck, 6x14 ft. in size, all edges to be equipped with eyelets 12 in. apart provided with two lacing cords.

F. Pillows.—The pillows are to be of 8-oz. single-filling duck, 6 ft. long and 18 in. wide, double; one end to be left open and equipped with eyelets and lacing cord.

G. Tent Heaters and Pipe.—The heaters to be of the type known as "Sibley" heaters. Each heater is to be provided with one piece of extra heavy riveted stovepipe, reducing from a 6-in. size to a 4-in. size, and three pieces of 4-in. extra heavy riveted stovepipe. The reducing piece to be equipped with damper and the top piece equipped with fine mesh spark arrester.

H. Packing Boxes.—Two strong, heavy pine packing boxes are to be constructed.

Box No. 1 to be 30 in. wide by 48 in. long by 24 in. high (inside measurements).

Box No. 2 to be 24 in. wide by 44 in. long by 20 in. high (inside measurements).

The top of each to be covered with galvanized sheet iron and all corners and edges to be covered with angle iron; each to be equipped with two padlocks and hasps; each to be equipped with four heavy iron handles.

A. TENTS.

Quantity and Name.	Packed in.	Description.
1 kitchen tent	Bundle	Wall—10 oz. D. F. duck, 12'x 14'-5' wall.
1 dining tent	Bundle	Wall—10 oz. D. F. duck special top, 16'x18', 5 ft. wall.
1 tent fly	Bundle	10 oz. D. F. duck, 12'x12'.
6 sleeping tents	Bundle	Round, 10 oz. D. F. duck, 16' in diameter.
200 tent stakes	Bundle	Long and heavy, for guy ropes of all tents.
200 tent stakes	Bundle	Short and heavy, for walls of all tents.
5 sleeping tent poles	Bundle	Each pole consists of two pieces of 1½" black iron pipe 5¾' long; each threaded on one end with coupling for same, one piece fitted on one end with cuff and spike.
4 wall tent poles	Bundle	All to consist of 1½" black iron pipe threaded and equipped with couplings. Each pole to consist of two pieces 5' long. Poles are for uprights of dining and kitchen tents.
2 wall tent ridge poles	Bundle	All to consist of 1½" black iron pipe threaded on each end, equipped with couplings. 3 pieces 6' long for ridge pole of dining tent; 2 pieces 6' long for ridge pole of kitchen tent.

B. KITCHEN EQUIPMENT.

Quantity and Name.	Packed in.	Description.
1 camp range	Crate	Six-hole steel range complete, less warming oven.
2 pieces stove pipe	Crate	6" for use with camp range.
2 frying pans	Box No. 1	Diameter 12".
4 bread pans	Box No. 1	Size 10"x14".
2 coffee boilers	Box No. 1	Enameled ware, 11 qts.
1 camp kettle	Box No. 1	13 qts. steel.
1 stove pot	Box No. 1	Steel diameter, 10¾"x8¼".
1 preserving kettle	Box No. 1	Enameled ware, 12 qts.
1 preserving kettle	Box No. 1	Enameled ware, 10 qts., 5⅜"x 11⅞".
2 sauce pans	Box No. 1	Enameled ware, 7½ qts., 5¼"x 11¼"x8¾".
2 tea pots	Box No. 1	Enameled ware, 4 qts., 8¼".
2 cake griddles	Box No. 1	
12 pie pans	Box No. 1	Enameled ware, ⅞"x9".
3 water buckets	Box No. 1	3 gal. heavy galvanized.
1 dish pan	Box No. 1	Enameled ware, 30 qts.
1 dish pan	Box No. 1	Enameled ware, 14 qts.
1 coffee mill	Box No. 1	
1 graduated measure	Box No. 1	
1 flour sifter	Box No. 1	
6 tin lids	Box No. 1	Hemmed and rings, diameter 11"-11½"-12"-12½"-13"-13½"-. Covers for kettles and pans.
1 meat saw	Box No. 1	
1 cleaver	Box No. 1	
1 butcher knife	Box No. 1	8" blade.
1 butcher knife	Box No. 1	12" blade.
1 butcher steel ladle	Box No. 1	12" steel.
1 pierced ladle	Box No. 1	
1 cake turner	Box No. 1	
1 colander	Box No. 1	Enameled ware, 5 qt.

1 dipper	Box No. 1	Enameled ware.
1 flesh fork		
1 potato masher	Box No. 1	
2 dredges	Box No. 1	For salt and pepper.
2 basting spoons	Box No. 1	18" long, enameled ware.
1 can opener	Box No. 1	
1 grater	Box No. 1	
1 funnel	Box No. 1	Enameled ware, 4⅜"x5½".
1 rolling pin	Box No. 1	
1 wire pot cleaner	Box No. 1	
12 grain sacks	Box No. 1	Heavy wheat sacks for protecting certain supplies.
1 alarm clock	Box No. 1	Encased in wooden box.
2 paring knives	Box No. 1	
1 wash tub	Box No. 1	Heavy galv.; diameter, top, 24½"; bottom, 21¼"; depth, 11".
1 wash boiler	Box No. 1	12"x22½".
2 wash boards	Box No. 1	
1 ice box	Crate	
25 yd. cheese cloth	Box No. 1	For dish and wiping cloths.
4 barrels	Box No. 1	To be equipped with tight covers, two for water and two for slop.

C. DINING EQUIPMENT.

Quantity and name.	Packed in.	Description.
36 plates	Box No. 1	Enameled ware, diameter 9".
36 cups	Box No. 1	2¼"x4¼".
36 tables knives	Box No. 1	
36 table forks	Box No. 1	
36 tea spoons	Box No. 1	
60 table spoons		
18 vegetable dishes	Box No. 1	Oblong enameled ware, 10½"x 7⅝"x2¼".
36 bowls	Box No. 1	Enameled ware, 2⅛"x5".
6 meat platters	Box No. 1	Enameled ware, 9½"x14 6/8".
6 bread trays	Box No. 1	1½" deep, 10⅛" diameter.
6 molasses pitchers	Box No. 1	Enameled ware.
6 milk pitchers	Box No. 1	Enameled ware.
6 spoon holders	Box No. 1	Enameled ware.
6 water pitchers	Box No. 1	Enameled ware, 5 qt.
6 sugar bowls	Box No. 1	Enameled ware.
6 salt shakers	Box No. 1	Aluminum self-righting".
6 pepper shakers	Box No. 1	Aluminum self-righting".
12 yd. oil cloth	Box No. 1	White, 36" or 48" wide. For dining tables and kitchen tables.
12 yd. mosquito bar	Box No. 1	To cover tables.

D. BEDDING.

Quantity and name.	Packed in.	Description.
18 stockman's bed sheets	Bundle	18-oz. duck, 6'x14'.
72 blankets	Bundle	Heavy woolen.
16 pillow cases	Bundle	Light canvas, 6"x18" (double).

E. MISCELLANEOUS EQUIPMENT.

Quantity and name.	Packed in.	Description.
12 lanterns	Box No. 2	
1 oil can	Box No. 2	5-gal., wood encased.
6 wash basins	Box No. 1	Enameled ware, 3⅛"x11⅝".
24 towels	Box No. 1	Large and heavy.
3 dippers	Box No. 1	Enameled ware, 2¼"x4⅝"x12".
6 tent heaters	Crate	Sibley. Only to be shipped out during cold weather when needed.
24 pieces stove pipe	Crate	Small, 4". Only to be shipped out during cold weather when needed for use in connection with heaters.

Grocery and Supply List for Camp Outfits.—Select from this list such articles as are needed. The quantity needed will depend upon the number of men in the gang and the length of time required to complete the job.

Special attention must be given toward the close of the job in ordering or buying groceries so that a very small quantity, if any, is left over.

A. CEREALS.

Name.	How ordered.	How purchased.
Oatmeal	By the case	Wholesale.
Corn flakes	By the case	Wholesale.
Corn meal (mush)	By the pound	Wholesale.
Rice	By the pound	Wholesale.
Cream of wheat	By the case	Wholesale.

B. MEATS.

Name.	How ordered:	How purchased.
Ham (cured)	By the number	Wholesale.
Bacon (breakfast)	By the number	Wholesale.
Bacon (bellies)	By the number	Wholesale.
Beef (fresh)	By the quarter	Wholesale.
Pork (fresh)	By the ½ hog or pound	Wholesale or locally.
Chickens	By the pound	Locally.
Eggs	By the dozen	Wholesale or locally.
Liver	By the pound	Locally.
Heart and tongue	By the pound	Locally.
Mackerel (salt)	By the pound	Wholesale.
Salmon (canned)	By the case	Wholesale.

C. VEGETABLES.

Name.	How ordered.	How purchased.
Potatoes	By the bushel or pound	Wholesale.
Onions (dry)	By the pound	Wholesale.
Onions (fresh)	By the dozen	Locally.
Beans (navy)	By the pound	Wholesale.
Beans (Lima)	By the pound	Wholesale.
Beans (string, canned)	By the case	Wholesale.
Tomatoes (canned)	By the case	Wholesale.
Tomatoes (fresh)	By the pound	Locally.
Peas (canned)	By the case	Wholesale.
Corn (canned)	By the case	Wholesale.
Corn (cob)	By the dozen	Locally.
Cabbage	By the crate	Wholesale.
Kraut	By the case	Wholesale.
Sweet Potatoes (fresh)	By the bushel	Locally.
Sw't potatoes (canned)	By the case	Wholesale.
Turnips	By the bushel	Locally.
Radishes	By the dozen	Locally.
Lettuce	By the bunch	Locally.
Hominy (canned)	By the case	Wholesale.

C. DRINKS.

Name.	How ordered.	How purchased.
Coffee	By the pound	Wholesale.
Tea	By the pound	Wholesale.
Milk (fresh)	By the gallon	Locally.
Milk (butter)	By the gallon	Locally.
Lemons	By the case	Wholesale.

E. DESSERTS AND FRUITS.

Name.	How ordered	How purchased.
Prunes	By the pound	Wholesale.
Gelatin	By the package	Locally.
Jelly	By the gallon	Wholesale.
Preserves	By the gallon	Wholesale.
Syrup	By the gallon	Wholesale.
Apples (canned)	By the case	Wholesale.
Peaches (canned)	By the case	Wholesale.
Pears (canned)	By the case	Wholesale.
Pineapple (canned)	By the case	Wholesale.
Cherries	By the case	Wholesale.
Blackberries	By the case	Wholesale.
Apricots (dried)	By the pound	Wholesale.
Ginger snaps	By the case	Wholesale.
Raisins	By the pound	Wholesale.

F. MISCELLANEOUS.

Name.	How ordered.	How purchased.
Bread	By the load	Locally.
Butter	By the pound	Locally or wholesale.
Milk (condensed)	By the case	Wholesale.
Crackers	By the case	Wholesale.
Sugar	By the pound	Wholesale.
Macaroni	By the case	Wholesale.
Cheese	By the number	Wholesale.
Vinegar	By the quart	Locally.
Mustard	By the bottle	Locally.
Catsup	By the bottle	Locally.
Pickles	By the keg	Wholesale.
Ice	By the pound	Wholesale or locally.

G. FOR COOKING PURPOSES.

Name.	How ordered.	How purchased.
Lard	By the pound	Wholesale.
Soda	By the package	Locally.
Baking powder	By the package	Locally.
Salt	By the package	Locally.
Pepper	By the package	Locally.
Starch (corn)	By the package	Locally.
Cinnamon	By the package	Locally.
Ginger	By the package	Locally.
Nutmeg	By the package	Locally.
Chilli pepper	By the package	Locally.
Tapioca	By the package	Locally.
Lemon extract	By the package	Locally.
Vanilla extract	By the package	Locally.
Flour	By the pound	Locally.
Corn meal	By the pound	Locally.
Currants	By the pound	Locally.
Raisins	By the pound	Locally.

H. SUNDRIES.

Name.	How ordered.	How purchased.
Soap (laundry)	By the case	Wholesale.
Soap (hand)	By the case	Wholesale.
Matches	By the case	Wholesale or locally.
Coal oil	By the gallon	Locally.
Brooms	By the number	Locally.
Sapolio	By the cake	Locally.

STANDARD UNITS FOR COMPARING MUNICIPAL IMPROVEMENTS.*

To the majority of city officials and taxpayers the one thing most readily understood about public work is its cost. Even engineers, to whom the technical and construction sides of such work are those of most interest, must also consider cost, and consider it most carefully. Not only because the closeness of agreement between their estimates and the actual cost is taken by many citizens as a measure of their ability; but much more because of the real practical importance of such close approximation.

The importance of close estimating is very apparent. If an estimate is excessively high, it may cause the voters to defeat a proposed improvement at the polls. If it proves to have been too low, the voters will be suspicious of all future estimates and may for that reason reject future improvements. Also, bond issues based upon low estimates place the city administration in an embrassing position.

Estimates must be based upon the cost of past work—I know of no other reliable method of estimating. And this means exact knowledge not only of how much was sent, but what was obtained for it. Unit costs are necessary for making estimates.

As to unit costs of work done, any taxpayer feels that he can understand dollars and cents, even though he may be hazy about paving materials and the methods of laying them. When, therefore, he learns that some other city is getting a certain kind of pavement at considerably less cost than his own, or that he is assessed more per front foot for a pavement laid on his street than his neighbor is for the same kind of pavement laid on another street in his city, he wants to know why and is entitled to a clear and definite answer.

There always is an answer, and it is generally a perfectly valid one; but the mere fact that explanations and excuses are necessary is apt to arouse suspicion, especially if there is anything indefinite about those given. How much better if explanations were unnecessary, or if, when required, they could be made so clear and concise as to convince any man of average intelligence.

---

*Paper read before the Seventh Annual Conference of Mayors and Other Officials of the Cities of the State of New York by A. Prescott Folwell, Chairman of the Committee on Standard Forms of the American Society of Municipal Improvements.

Why taxpayers might have an excuse for asking explanations and why engineers may have difficulty in making estimates based on costs may be made clear by a few illustrations taken from our own state.

Take sheet asphalt, for instance. The method of constructing this is standard and there should be no great difference between the costs of it in several cities in the same section of the country. But in 1915 this pavement cost Geneva, N. Y., $1.25 per square yard and Troy, $2.23. It looks as though Troy taxpayers had some explanation coming to them.

Syracuse paid $1.87 in 1914 and $1.99 in 1915—an increase of 12 ct. But Albany paid $2.14 in 1914 and only $1.74 in 1915—a decrease of 40 ct. What is Syracuse's explanation?

Or take brick pavements. In 1915 Dunkirk laid these for $1.39 a square yard, while Troy paid $2.85—more than twice as much. Syracuse paid $2.05 in 1914 and $2.37 in 1915—an increase of 32 ct.; while Salamanca paid 36 ct. less in 1915 than in 1914, or $1.89 as compared with $2.25. I have no figures for Buffalo for 1915, but she reported for 1914 a cost of $3.29 for brick pavement—nearly two and a half times as much as Dunkirk; and $3.53 for asphalt, or nearly three times as much as Geneva.

One thing is sure—there was not actually all this difference in costs, and it is evident that these figures are for some reason not comparable—that the thing which Buffalo calls paving is not the same as that to which Dunkirk applies that name. And what Syracuse did for $2.05 in 1914 was not, I believe, the same as that for which she paid $2.37 in 1915.

As Buffalo is the most "horrible example," let us see what she paid $3.53 for in 1914. Included, beside the pavement, some grading, setting new curb, laying a drain, probably other general work like resetting manhole heads, and a 10-year guarantee. Another city, not in this state, has gone far ahead of this, however, for she includes under the head and price of paving, all excavation, curb, storm sewers, adjusting manhole heads, building catch basins and even grading the private property along the street. I see no reason why that city did not include lighting standards, wire conduits, shade trees and other street accessories, except that perhaps they were already in.

All these things are street improvements, but they are not paving, and to call them so seems absurd.

Moreover, to explain that a certain cost includes grading and setting curb does not help us to compare this cost with another—it only shows that such comparison would be useless, unless we know just what part of the cost was to cover each of the non-paving items.

The total cost of these non-paving items may be considerable. For instance, in 1915 Walden, N. Y., laid a brick pavement which cost $1.84 for the pavement and foundation, but $2.34 if excavation and other improvement items be included. This is an average and not an extreme case. In some cases the additional items will amount to even more than the paving.

It may be claimed by some cities that under their methods of assessment the property owner is to be assessed for the total cost of the improvement, and therefore this is the cost desired. This is all right, if you call this street improvement and not paving. But even in this case, itemizing costs is of great value, as will be shown in a minute; and if the cost were itemized, a school boy could get the total cost per front foot in five minutes by a little multiplication and addition; while if the bids or records give only the total cost, not even a paving expert can "unscramble the eggs" and tell what the paving alone cost.

Some prefer a "lump sum" bid, so that no extras can be worked in on the payment. But the same end can be reached by receiving itemized bids, and adding a "residuary item" clause, asking a price for all work necessary to complete the job according to plans and specifications, but not covered by the other items.

Costs.

The advantage of having bids or costs for each item is, I think, apparent with a moment's thought. If we know what it costs each city in the state or in the country to lay a square yard of standard brick pavement, exclusive of excavation, curbs or any other items, then we have figures which are directly comparable. We can tell whether neighboring cities really did get more for a dollar than we did. We can show the taxpayers, without dubious explanations, that they are getting more for their money this year than they did last. If A complains that his street improvement assessment is higher than that of B who lives on the next street, we can show him that it is because there was more grading to be done on his street, or more curb to be set, and that the paving itself does not cost him a cent more. The probability is, however, that the facts will appear so plainly in the published figures that we will not need to explain at all.

In the previous remarks, paving has been used for illustration, but the same ideas apply to sewer construction or any other kind of public work. It is only when costs are itemized that cost records of such work will be of value for making future estimates, or making comparisons with costs of previous years or of other cities.

A. S. M. I. STANDARD UNITS FOR STREET PAVING

If these units are used, a statement to that effect in a report or description, without further explanation, gives certainty of meaning to the figures.

PAVEMENT: The wearing surface down to the base, if any Includes cushion or binder course, but not concrete, macadam, or other base. If base is included, describe as "pavement and........inch concrete macadam base." In the case of macadam or concrete pavement, the term includes all down to the earth foundation. *Unit, the square yard*, giving material and thickness. Ex.: 1524 sq. yds. of 3 in. asphalt pavement.

BASE: The concrete, macadam or other material placed under the pavement to distribute the load on the subgrade. *Unit, the square yard*, naming thickness and material. Ex.: 1524 sq. yds. of 6 in. concrete base.

EXCAVATION; EMBANKMENT: All material removed before laying base, curb or sidewalk; or all material added, up to base, curb or sidewalk. *Unit, the cubic yard*, naming material. Ex.: 600 cu. yds. of earth excavation.

CURB: Complete construction of new curb, except excavation or embankment. **RESETTING CURB**: Same, except furnishing of curb stone. *Unit, lineal foot*, stating (in inches) depth and mean width of curb, and material. Ex.: 952 ft. of 7 x 18 granite curb reset; 750 ft. of 6 x 16 concrete curb.

GUTTER: Same as curb. *Unit, square foot*, stating thickness and material. Ex.: 1428 sq. ft. of 6 in. concrete gutter.

SIDEWALK: The artificial wearing surface, not including excavation or embankment, nor base of cinders or other material, if any. *Unit, the square foot* (or square yard, if preferred) giving average thickness and material. Ex.: 1720 sq. ft. of 6 in. concrete sidewalk.

SIDEWALK BASE: Cinders or other material placed under sidewalk. *Unit, the cubic yard*, naming material. Ex.: 122 cu. yds. of gravel sidewalk base.

A. S. M. I. STANDARD UNITS FOR SEWER CONSTRUCTION

If these units are used, a statement to that effect in a report or description, without further explanation, gives certainty of meaning to the figures.

CONSTRUCTING SEWER: Excavating trench (except rock and street pavement), furnishing material for and constructing or laying the sewer barrel (not including branches, manholes or other appurtenances, special foundations, etc.) and backfilling (not including relaying pavement) Excavation of rock, sheathing left in trench, and removal and replacing of pavement paid for extra. Depth of excavation is measured from street surface to invert of sewer, and classified by two-foot intervals. *Unit, the lineal foot* (measured along the entire length of the sewer, including manholes and specials), naming size of bore and material of sewer, and depth. Ex.: 10 in. vitrified sewer, 950 ft. 8 to 10 ft. deep: 630 ft. 10 to 12 ft. deep.

BRANCHES: Y or T branches inserted in the sewer: the price paid to be additional to that paid for the sewer in which the branch is inserted.

MANHOLE: The total structure, including bottom and top casting, steps, etc., additional excavation and backfilling. Standard to be taken as 6 feet deep, and depths exceeding this to be given in additional feet depth. Price is in addition to that paid for sewer (measurement for which includes manholes, as stated above.) *Unit, manhole of standard depth*, giving bottom diameters in feet; and feet of additional depth. Ex.: 7 manholes 3 x 4½, and 22 ft. additional depth. (This means that the sum of the depths was 64 ft., and the average depth was 9 1/7 ft.)

REPLACING PAVEMENT: Grading top of trench back-fill, putting in pavement foundation (if any), and laying wearing surface (replacing any material damaged in removing same.) *Unit, square yard*, naming kind of pavement. Ex.: removing and replacing 726 sq. yds. of brick pavement.

Such itemizing is essential for obtaining efficiency and economy. How can we expect to cut down costs if we do not know what items are high ones? Can a manufacturer know how to increase his profits if his accounts show, not what individual items cost him to produce and market, but only his total profit or loss for a year?

Standard Units.

If the only aim is to compare costs in your own city and on work done by you individually, then each man might select his own units for measuring and expressing quantities of work. But how much more valuable his cost records would be if he could compare them with those of all other cities and of previous administrations in his own city!

This means that he and all others should use the same units. That when he says "a square yard of asphalt pavement" he means exactly the same thing as every other man who uses the term.

A very considerable number of cities do keep their records and receive their bids itemized as described; but they find the undoubted value of this is lessened by the fact that not all use the same units for measuring the work done, or use them with exactly the same meaning.

To remedy this condition, the American Society of Municipal Improvements has, after two or three years' consideration, adopted a few of the more important units for paving and sewerage, which it recommends as standards for universal use. This society numbers among its members most of the leading city engineers and consulting engineers on municipal work, and it is to be presumed that the units which it adopts will be those best adapted to the purpose which seems practicable at this time. The standard paving specifications which the society has prepared are now generally accepted as the standards for the country, and it hopes that its standard units also will be generally adopted. When each standard kind of pavement is laid by everyone according to a standard method and measured with a standard unit, we will then be able to make comparisons which will have a real value—which we are not able to do now.

DESIGN AND FABRICATION OF THE TUBES FOR THE HARLEM RIVER FOUR-TRACK SUBWAY TUNNEL.*

By Olaf Hoff, Consulting Engineer, New York City.

The Harlem River tunnel forms a link in the Lexington Ave. subway system now under construction by New York City. Together with about 1,500 ft. of approaches, it forms contract No. 14 of the Lexington Ave. subway, this section beginning half way between 128th and 129th Sts., Manhattan, and extending to the beginning of Mott Ave. on the Bronx side. The tunnel thus connects the boroughs of Manhattan and the Bronx. It runs under the river in very nearly a direct line north and south, forming an angle of approximately 45° with the direction of the current. The section has a total length of about 2,630 ft., of which the subaqueous tunnel extends 1,080 ft.

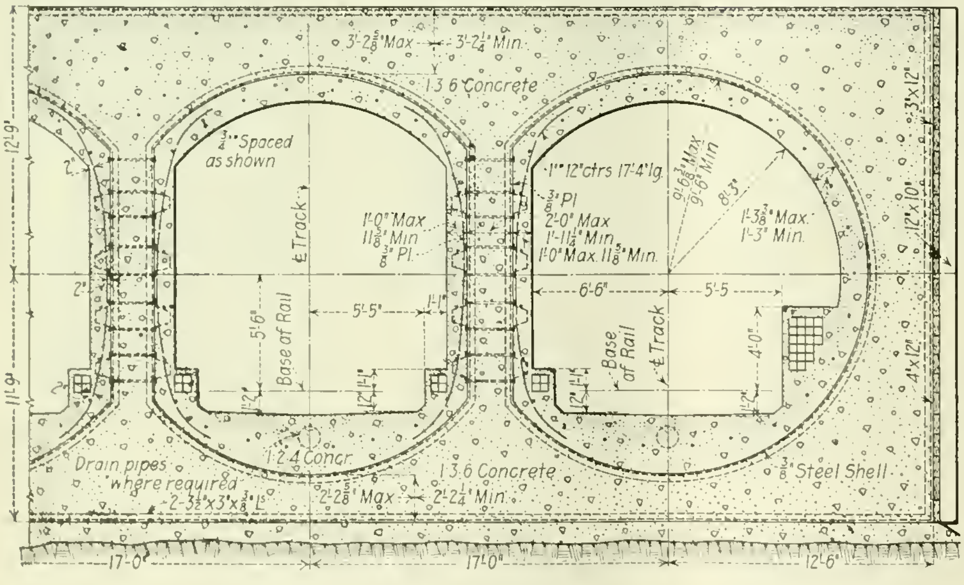


Fig. 1—Cross Section of Two of Four Tubes of Harlem River Tunnel of Lexington Avenue Subway, New York City.

The Lexington Ave. subway is a four-track structure, two tracks of which are for express service and two for local service. Generally it is built as a double-deck structure, the two local tracks being on the upper deck and two express tracks on the lower deck. Under the Harlem River these four tracks are brought to the same level and are carried under the river in four separate tubes, constructed, however, as one unit. The roof of the tunnel, in accordance with the requirements of the War Department, is placed at such an elevation as to give a navigable depth of water at low tide of 25 ft., or at mean high tide of a little over 30 ft.; in other words, designating mean high water as elevation 100, the top of the tunnel roof is placed below elevation 70, while the bottom of the tunnel structure is at about elevation 41.5. The general level of the river bottom is approximately at elevation 75.

The approaches are brought on a 3 per cent grade towards the river crossing, which is nearly on a level between the bulkhead lines, having merely a 0.3 per cent grade to a sump located about 400 ft. from the northerly end of the tubes. North of the sump the river tubes are on a 3 per cent grade and a vertical curve. At the south end they are on a vertical curve and also, for a distance of 30 ft., on a horizontal curve.

Design of Steel Tubes.—Figure 1 is a cross-section of two of the four tubes comprising the subway. It will be noted that the tunnel section consists of steel tubes, lined and encased with concrete. The purpose of the steel tubes is, in the first place, to serve as a form for the exterior concrete; they also serve the purpose of waterproofing, and add materially to the strength of the tunnel. The steel tubes are 19 ft. in diameter and are spaced 17 ft. center to center.

The outside of the outer tubes form a circle, but where adjacent to each other the sides are flattened and spaced 2 ft. apart. The tubes were built in five sections, three of which (A, B and C) were 220 ft. in length; one (Section D, the northerly end section), 219 ft., and one (Section E, the southerly end section), 199 ft.; making a total length of the five sections of 1,078 ft. over all, of the steelwork. The tubes are built of ⅜-in. steel plate and are reinforced every 15 ft. 7 in. along their axis with ¼-in. steel diaphragm plates, which extended 2 ft. 3 in. below the bottom of the tube, 3 ft. 3 in. above the top, and 3 ft. beyond the outside tubes; the diaphragms thus measure 24 ft. 6 in. in depth and 76 ft. in length. They are connected to the tubes by means of 3½x3x⅜-in. angles and their edges are stiffened by double angles of the same dimensions. Along the vertical sides of the diaphragms there was bolted, edge to edge, a solid layer of planking 4 in. thick for a height of 11 ft. 6 in. from the bottom, and 3 in. thick for the remaining 13 ft. Half way between the diaphragms the tubes were stiffened by a circumferential angle 4x3x½ in., placed on the outside of the tubes, to which the planking was fastened at the middle by means of short angle braces for the purpose of providing additional support.

The flattened sides of the adjacent tubes are held together by means of 1-in. diameter bolts, spaced 2 ft. 3 in. apart longitudinally and with a vertical spacing of 15 in. near the bottom of the flattened sides, varying to 18 in. at the top. The bolts have two nuts at each hand, one on each side of the shell plate.

Yokes or straps of 2½x¼-in. steel are fastened inside of the flat sides, using the same bolts, thereby tying the concrete lining of the adjacent tubes together as one mass.

The flattened sides are provided with openings 4x9 ft. to make the tubes accessible, one from the other. These openings are only two in number in the central partition wall, spaced equidistant from each other and the ends of the tubes. In the two other partition walls these openings come approximately 50 ft. apart. At the sumps a larger opening was provided in these walls, in which the pumps are situated. The sumps are two in number, one for each pair of tubes; each sump has a capacity of 3,000 gal.

The diaphragms serve the threefold purpose of stiffening the tubes, of holding them rigidly together, and, together with the planking on the sides, of forming a series of pockets, open at the top and the bottom, into which the exterior concrete could be filled.

It is assumed, when the steel tubes are unwatered, that the shell is exposed to a full hydrostatic pressure—transmitted through the exterior concrete—at all points, which pressure it is capable of resisting, as the exterior concrete holds it in place, preventing deformation.

---

*Extracts from paper in Proceedings, the Engineers' Society of Western Pennsylvania.

The amount of exterior concrete required is controlled by the fact that, when the tubes are unwatered, there must be sufficient weight in the structure to hold it down with a safe margin. The excess of the weight of the exterior concrete and the steel tubes over the buoyancy of the mass amounts to a trifle over 1½ tons per lineal foot of tunnel for the four tubes. The amount of exterior concrete thus determined, in turn determines the lateral dimensions of the diaphragms.

Assembling of Tubes.—The steel tubes were fabricated by the American Bridge Co. and were shipped "knocked down." They were assembled, riveted up, and caulked by the general contractors for the tunnel. This was done in a slip in the Harlem River rented for the purpose and located about a mile west of the tunnel site. A falsework was driven in the slip consisting of four rows of piles, in which the piles were spaced 15 ft. 7 in. on centers and capped longitudinally with two 12x12-in. timbers on the top of each other. Crosswise of this slip, these rows were spaced equal distances apart so as to bring the last rows just underneath the vertical sides of the diaphragms, thus giving each diaphragm four points of support.

On the bulkhead at one side of the slip there were mounted two derricks with their respective hoisting engines. These derricks were used for erecting and the outer one for unloading as well, all the steel being delivered by lighter.

On the opposite side from the bulkhead a trestle was built in the slip with a track about 15 ft. above high tide. On the track of this trestle, which ran parallel with the tubes, there was operated a locomotive crane with extension boom long enough to place the steel plates for the second tube away from it; in other words, between the two derricks on the one side and the locomotive crane on the other side, all steel for the tubes could be set and assembled.

An air compressor with necessary boiler, etc., capable of furnishing 450 cu. ft. of free air per minute, supplied power for 11 riveting hammers, 8 caulking hammers and 2 reamers, which comprised the maximum equipment used at any one time.

The tubes were built complete in the slip, and the wooden sheeting along the edges of the diaphragms were bolted on before they were launched. At the ends they were fitted with bulkheads so that when launched they would float on their own bottoms. These bulkheads were placed at the last diaphragm, and, except as noted later, served the purpose only of floating the tubes and controlling the sinking. The bulkheads of the outer tubes were carried all the way up to the roof, while the inner tubes had low bulkheads reaching from the bottom of the shell to only a couple of feet above the flotation line of the tubes after launching. These bulkheads were of light construction and consisted of 8x10-in. uprights, spaced 5 ft. on centers, to which was fastened 3x12-in. yellow pine planking, running horizontally, with the ends trimmed to fit the steel shell and bearing against a 3½x3x⅜-in. angle riveted to the inner circumference of the shell.

At the southern end of section A (the first section sunk) and at the northerly end of section D (the fourth section sunk) the bulkheads were constructed to resist the full hydrostatic pressure, and all four bulkheads extended to the roof of the tunnel. The object of this was to permit the four sections, A, B, C and D, to be pumped out and lined before sinking and concreting section E. These bulkheads were made of rolled steel beams, provided with extra flange plates, placed in an upright position, and spaced 3 ft. 9 in. on centers. To these beams there were fastened 6x12-in. yellow pine timbers placed flatwise against the beams. They were fitted against the shell and provided with bearing at the ends, as before described. All bulkheads were caulked with oakum. The bulkheads of the outer tubes of the first section were provided with 12-in. inlet valves; these were dispensed with in the subsequent sections as it was found quite as convenient to saw out a couple of planks in the low bulkheads of the middle tubes to let the water in; from the middle tubes the water could flow into the outer tubes through suitable openings provided in the wooden partitions, which were placed in the 4x9-ft. openings of the partition walls of the tubes in order to prevent too rapid an inflow of water from the center tubes to the outer tubes.

The outer steel tubes were further provided with semi-bulkheads placed three pocket lengths or about 47 ft. from the bulkheads at the ends. These semi-bulkheads extended from the top of the steel tubes down to about 2 ft. below the center line and served the purpose, during sinking, of trapping the air at the ends of the tubes and thus prevent the tubes from plunging endwise before they were caught up by the air cylinders on top. These semi-bulkheads were also of light construction similar to the light bulkheads at the ends.

Four detachable steel masts were attached to the outer tubes, one at each end and of sufficient length so that when the tubes were in their permananet position in the bottom of the trench, at least 10 ft. of the mast would be visible above the surface of the water. At the upper end of each mast was clamped a thin metal plate divided into feet and tenths, which served the purpose of a level rod. To each mast was further clamped a cross arm with a target, the center of which was placed 1 ft. to one side of the actual center of the outer steel tube. By this means a transit set up in proper position could place both ends of the tube in their proper alignment, while a level instrument on the bank was placed so as to read the level on all four masts.

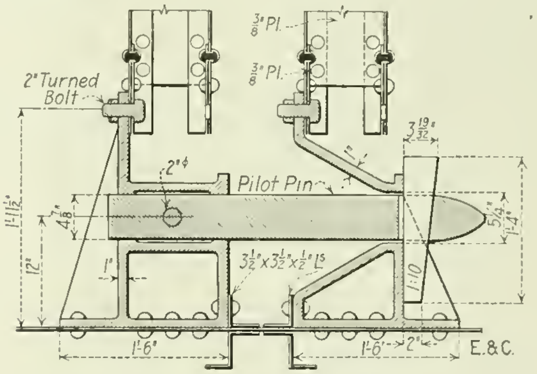


Fig. 2—Details of Pilot Pin and Socket Used in Connecting Sections of Tubes of Harlem River Tunnel.

In order to connect a section of tubes to be sunk with the section in place the ends were provided with an exterior angle 3½x3½x½ in. and an interior Z-bar 4x⅜ in. The angle was placed with the back away from the end, and was fastened to the shell with the same row of rivets connecting the Z-bar to the shell; the web of the latter came in the same plane with the outstanding leg of the angle, with the inner flange of the Z-bar pointing away from the end of the tube. The tubes butted end to end and were bolted together by means of ⅞-in. bolts spaced about 18 in. apart and passing through the outstanding leg of the exterior angle. These bolts were inserted by divers.

After the tubes were unwatered a ⅜-in. plate, 13½ in. wide, was bolted to the inner and outstanding flange of the Z-bar and the pocket formed between this plate, the Z-bar and the shell was filled with grout.

In order to bring a section into its true position so as to connect it to the adjoining section there was provided at each end of the two outer tubes the pin-and-socket arrangement shown in Fig. 2. On the section already in place there was bolted a funnel-shaped casting, or socket, with the funnel pointing towards the next section. This casting also formed a support for the mast. On the corresponding end of the next section there was bolted a casting in which rested a pilot pin 4⅞ in. in diameter, 3 ft. 5 in. long, and turned down to a point. This pilot pin fitted into the narrow end of the socket and had a slot in which a key was inserted by the diver when the pilot pin had passed through the funnel casting, thus effectually locking together the two sections.

The total weight of metal in each of sections A, B, C and D is about 600 tons, and the amount of lumber about 60,000 ft. B.M. Section E contains about 533 tons of steel and 56,000 B.M. of lumber, this section being shorter by 20 ft. than the others. The larger sections required about 80,000 field rivets. Section A was built complete in 42 working days, section B in 32 days, section C in 31 days, section D in 25 days, and section E in 20 working days.

Personnel.—The work was carried out under the direction of the engineers of the Public Service Commission of New York City, Alfred Craven, chief engineer; Robert Ridgeway, engineer of construction. The steel tubes were fabricated by the American Bridge Co., and were assembled, riveted up and caulked by the general contractor, The Arthur McMullen & Hoff Co., of New York.

METHODS OF MAKING FIVE CIRCULAR REINFORCED CONCRETE RESERVOIRS WATER-TIGHT.*

By Dabney H. Maury, Consulting Engineer, Chicago, Ill.

The five reservoirs were constructed with reinforced concrete walls and had the following capacities: One, 2,000,000 gal.; two, 4,000,000 gal.; one, 10,000,000 gal.; one, 7,500,000 gal. One of the 4,000,000 gal. reservoirs was new and the other was constructed by adding to the wall height of an existing structure. The three other reservoirs were new.

2,000,000-gal. Reservoir.—The leakage when the reservoir was first tested was not much over 3,000 gal. per 24 hours. The contractor at first unwisely tried to stop the leaks by washing the inside of the reservoir, first with Sylvester mixture and then with cement. These coatings failed to adhere, and were of no value in stopping the leaks. No cracks of any sort could be detected in the reservoir even with the aid of a magnifying glass. The horizontal planes between successive pourings of concrete were plainly visible, and it was recommended that these be dug out in V-shaped grooves, running all around the reservoir, and having a depth of about 1½ in. and a width of 1 in. at the surface, and that these grooves be carefully filled with a mixture of ironite and cement. This was done and the leakage was effectually stopped.

4,000,000-gal. Reservoir.—The construction of the 4,000,000-gal. reservoir developed some surprising results. The enlargement to the old reservoir was built by the same contractor who built the new reservoir, the two jobs being parts of the same contract. The new reservoir was built first, and the enlargement to the old reservoir was made after the new reservoir had been put in service. The contractor was required to guarantee the watertightness of the finished work.

After the award of contract the writer discussed with the contractor the methods which he planned to employ in building the reservoir, and was informed that he intended to erect an elevator tower between the two reservoirs, construct the forms for the whole 32 ft. in height of wall, and place his concrete in the wall by means of chutes, working day and night and pouring the concrete continuously until the entire wall was poured. The writer objected strongly to this method of construction, and spent much time in endeavoring to persuade him to abandon it, and to use removable forms not more than 2 or 3 ft. in height, so that the concrete could be thoroughly spaded in place in the wall. Sketches of such forms were prepared, and estimates secured on steel forms which seemed to prove that they would be much cheaper than the wooden forms contemplated by the contractor. The contractor, however, argued that he had in stock a lot of lumber which could be used for forms and which he could so manipulate that it would suffer very little damage from such use. He further stated that he was afraid that leaks would occur in the joints between successive pourings, and he claimed, with some justice, that so long as he was compelled to guarantee the final results, he was entitled to use any method of construction which he saw fit, provided the contract and specifications did not expressly forbid the use of that particular method. Finding himself unable to persuade or compel the contractor to change his method of construction, the writer was obliged to allow the work to proceed.

In the meantime the contractor asked permission to use a cement with which the manufacturers mixed at the mill a certain alleged waterproofing material. This cement, so mixed, was subjected to the usual laboratory tests by one of the city engineers who had charge of the supervision of the construction work on the ground, and passed successfully all of the tests applied, complying with all of the requirements of the standard specifications of the Society for Testing Materials. Permission was accordingly granted to use this brand of cement, subject always to the provisions of the contractor's guarantee of the final results.

Construction work proceeded rapidly, and it was evident that the contractor was doing all that could be expected of him to secure good results, but when the forms were removed, the entire surface of the wall was seen to be spotted with patches of a creamy or yellowish color. Investigation showed that wherever these patches occurred the material could be readily dug out of the wall with a pen knife, and this material contained no sand or stone, was almost as porous as a sponge or a piece of coral, and was so light that a lump of it would float in water. It was then evident that the so-called waterproofing mixture was of a soapy nature, and that when the concrete was poured down the chutes to its place in the wall, this soap formed a lather which separated from the stone and sand and from most of the cement, and lay on top of the rest of the ingredients. Just enough of cement appeared to remain in this lather to cause it to take a set.

There were hundreds of these soft spots, most of which extended entirely through the wall, the largest being about 25 ft. long by 3 or 4 ft. deep. The contractor did his best to dig them all out and put good concrete in place of them, but as might be expected, the reservoir still leaked after this had been done.

It was finally necessary to put in a membrane lining of waterproofing material over the wall and bottom, and to cover this with a protecting coat of several inches of reinforced concrete. This produced a watertight reservoir.

In the construction of the enlargement to the old reservoir, it is needless to say that the contractor did not pour all of the wall at one pouring, and that he did not use the so-called waterproofing substance. When the forms were removed from the second piece of work there were a very few small leaks which either stopped themselves in a short time, or were stopped without much difficulty.

10,000,000-gal. Reservoir.—Notwithstanding the fact that the price which the contractor for this reservoir received yielded him no profit whatever on the job, he spared no expense to make his work first-class in every particular, and he succeeded in this respect better perhaps than the contractors for any of the other reservoirs herein described. The photograph shows the wall of the reservoir completed, while the grading outfit is still engaged in removing the dirt from the center. Most of the excavation was done with a Page bucket, or dragline scraper.

After the forms were removed from the wall the space between the embankment and its outer surface was filled with water to test the wall for leakage. The inner surface of this wall was 942 ft. long by 15 ft. high, and in this entire area there were but three spots which showed any dampness. From one of these there was a small trickle amounting to only a few drops per minute.

There were no spots on the entire inner surface where stone showed against the forms, and this result was largely due to a device for which the contractor should be given credit. In building the wall a portable plate of thin metal was held at all times about ¾-in. away from the inner form, and as each batch of concrete was poured behind this plate, 1 to 1 cement mortar was poured in front of the plate and between it and the inside form, in quantities sufficient to keep the upper surface of the mortar level with the upper surface of the last batch of concrete. These plates were moved ahead as the pouring progressed around the circumference, being from time to time drawn up so that the mortar in front of them could unite thoroughly with the concrete behind them before either had time to begin to set. The excellent results obtained in this work were due in part to this device of the contractor, and in part to the conscientious thoroughness which characterized all the rest of his work.

---

*Extracts from a paper read before the American Water Works Association and published in the Journal for June, 1916.

7,500,000-gal. Reservoir.—When this reservoir was finished and tested by filling the space between the outside of its wall and the surrounding earth with water, a number of spots showed on the inside, and there were two or three small streams which spurted out from the inner surface of the wall. When the reservoir was filled and the loss of water measured with a gauge, it was found that this amounted to about 32,000 gal. in 24 hours, of which a very small part was due to evaporation. The wall of this reservoir was poured in 4-ft. layers, and steel dams 8 in. high and ⅛ in. thick were provided at each construction joint for the purpose of minimizing the tendency to leakage at these joints. Incidentally these dams, which were butted to the vertical channels, assisted materially in the erection of the channels. There was only one leak of any size at a construction joint and at this spot the surface of the joint had been covered by a piece of clay from the bank above, and the contractor had evidently failed to remove this clay.

The specifications for this reservoir called for the use of a vacuum cleaner for cleaning the surface of the concrete already poured before fresh concrete should be poured on top of it. The work was not, however, supervised by the writer, and this provision was not carried out, the contractor simply brushing the joints in the usual manner before pouring the next batch of concrete. This brushing of the joints cannot give the best results for the reason that the dust and rubbish and laitance are simply moved from one point of the surface to another, whereas if a vacuum cleaner were used they could be removed entirely.

Conclusions.—As a result of his experience with these and with a number of other concrete reservoirs, the writer would draw the following conclusions:

1. It is entirely possible with proper materials, mixture and workmanship to prevent moisture from passing through a concrete wall a foot thick even under fairly heavy pressures.
2. It is not to be expected, however, that the perfection of workmanship required to produce these results will always be obtained at every single point over an area of thousands of square feet of wall.
3. Such leaks as may show in spite of conscientious efforts to do good work can almost invariably be stopped entirely or be reduced to such a point that they will stop themselves in the course of time, especially if the water carries iron or sediment.
4. Leaks are most likely to occur at construction joints. The use of steel dams will reduce the danger of such leaks, but these dams cannot always be relied upon to prevent the leakage, and their presence should not be allowed to diminish in any way the precautions which should always be taken to prevent leakage at the joints.
5. The surface of concrete which has begun to set should be scratched and roughened, and all dust, rubbish and laitance should be carefully removed with a vacuum cleaner before the next batch of concrete is poured. This will not always prevent leakage, but will go far towards doing it.
6. In reservoir construction the use of chutes for conveying concrete to its place in the wall should not be permitted unless the concrete is thoroughly remixed just before it reaches its final place in the wall.
7. While good results can be obtained by very careful spading of the concrete adjacent to the forms, so as to keep the stone away from the inner surface of the wall, it is believed that far better results would be secured by the plan devised by the contractor for the 10,000,000-gal. reservoir already described; namely, the use of a portable sheet of thin metal with means for holding it about ¾ in. away from the inner form, the concrete to be poured back of this sheet of metal, and cement mortar in front of it and between it and the form.

THE MATHEMATICS OF VERTICAL CURVES.

Contributed by Leonard C. Jordan, 243 Ryerson St., Brooklyn, N. Y.

Vertical curves connecting street or railroad grades are generally spoken of as parabolas while occasionally those who use them are not aware of the exact nature of the curve. The following numerical example will illustrate the facts in the case.

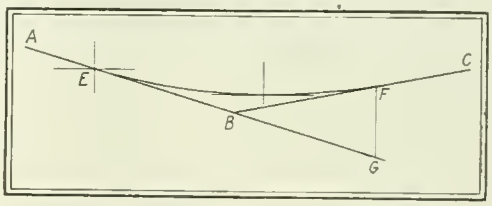
A 3 per cent downgrade AB is connected to the 2 per cent upgrade BC by the 500 ft. vertical curve EF. The problem consists of finding the elevations along the grade ABG, computing the ordinates above this grade by means of the equation

$$y = mx^2, \qquad (1)$$

using the point E as origin, and adding the ordinates to the corresponding elevations in the grade line; x may be taken in either feet or 100 ft. stations, the resulting value of m keeping y in feet. We will express x in feet; x is measured horizontally and not inclined, as all such surveying measurements are on the level; y, however, is the ordinate from the inclined grade ABG. In this example, BF is 250 ft. and FG is 12.5 ft. Then, from the coordinates at F, $m = y/x^2 = 12.5/250,000$. The equation is

$$y = x^2/20,000. \qquad (2)$$

If x had been expressed in stations, m would have been ½. Such curves, in which the length is 100 ft. for each per cent of change in grade, are sometimes spoken of as "One per cent curves."



For the purpose of investigation, let us transfer this curve to rectangular axes with the point E as origin. The new ordinate we will call y_1, and for any distance x the new y_1 is equal to the old y minus the drop in the grade. That is, $y_1 = y - 0.03x$, which reduces to

$$y_1 = x^2/20,000 - 0.03x. \qquad (3)$$

The lowest point on this curve is where dy_1/dx is zero. $dy_1/dx = x/10,000 - 0.03$. This is zero where x is 300, and at this point y_1 is -4.5. The co-ordinates of the lowest point being 300 and -4.5, transferring to new axes with this point as origin, and denoting the new variables as X and Y, we have $(Y - 4.5) = (X + 300^2)/20,000 - 0.03(X + 300)$. Performing the indicated multiplications, $Y = 4.5 + X^2/20,000 + 0.03X + 4.5 - 0.03X - 9$, which reduces to

$$Y = X^2/20,000. \qquad (4)$$

This is numerically the same expression as that with which we started, but this time it is the equation, in rectangular co-ordinates, of a parabola whose vertex is at the origin and axis vertical.

To prove that this curve is tangent to the two grades and does not intersect them: We already know that it touches the grades where X is -300 and $+200$. The slope of the curve at any point is $dY/dX = X/10,000$. At the point E, where X is -300, $dY/dX = -300/10,000 = -0.03$, the slope of the grade AB. At the point F, where X is $+200$, $dY/dX = +200/10,000 = +0.02$, the slope of the grade BC.

Since the curve is a true parabola tangent to the two grades and with its vertex at the lowest point (or highest point in the case of grades meeting at a summit), the elevations may be computed in the usual manner by using either end as the origin. Further, when the elevations of many points are desired and the x distances from the two extremities to points on the adjacent halves of the curve are equal, the y values for half the points should be computed and used twice by working in from each end.

In the example given, the ordinates are considered as being positive when measured upward. When grades meet at a summit the curve is entirely below the inclined axis from which y is measured and the more convenient plan is to consider the y value as being positive when measured downward, merely subtracting the ordinates from the elevations of corresponding points on the grade line.

Frequently it is necessary to determine the elevations of a vertical curve at many equidistant points, and then a certain property of the parabola may be used to eliminate much of the work. This property is the oft-overlooked relation between the elevations of equally spaced points. The "second differences" of these elevations are equal to each other. While this principle is sometimes employed as a check, it may save more than half the work, unless the numbers are peculiarly awkward, as will be illustrated now.

In the foregoing example the elevations at ten-foot intervals will be found. Ordinarily this would require the computing of the elevations of fifty points on the grade EBG, looking up the squares of fifty values of x, multiplying each of the latter by the factor m to get the corresponding values of y, and adding to obtain the elevations on the curve. Then all the work would have to be checked over. The work is greatly abbreviated by the following process.

Let us assume that the point B is located at station 138 + 64 with elevation 91.263 and that the points under consideration are the even plus tens. E is at station 136 + 14 with elevation 98.763. We will begin in the ordinary manner, going a little farther than necessary. The points desired are 136 + 20, 136 + 30, etc. The x distances are 6, 16, 26, etc. The resulting figures are given here in tabular form:

Station.	Grade.	x	y.	Elevation.	Diff.	2nd diff.
136 + 14.......	98.763	0	0	98.763		....
					....	
+ 20.......	98.583	6	.002	98.585		....
					.289	
+ 30.......	98.283	16	.013	98.296		.010
					.279	
+ 40.......	97.983	26	.034	98.017		.010
					.269	
+ 50.......	97.683	36	.065	97.748		....

Since we now have a start, we may make use of the constant "second difference" to find the "difference" between the elevations of adjacent points, i. e., by subtracting .010 each time. We can now suspend use of the equation of the curve and proceed as follows, repeating the last line of the preceding table:

Station.	Elevation.	Diff.
136 + 50............	97.748	
		.259
+ 60............	97.489	
		.249
+ 70............	97.240	
		.239
+ 80............	97.001	
		.229
+ 90............	96.772	
		.219
137 + 00............	96.553	
		Etc.
Etc.	Etc.	

Each elevation is derived from the preceding by subtracting the corresponding "difference." This process is continued throughout the curve. The "difference" will change signs as the lowest point of the curve is passed and will have to be added beyond that point. It will be noticed that an error in any addition or subtraction will affect all following work. Therefore an independent check on any point by the ordinary method will prove all preceding figures to be correct. Readers are cautioned against employing this method unless the "difference" and "second difference" are carried out to the last significant figure.

The so-called "second difference" is always the square of the x interval multiplied by twice the factor m. In the stated example the "second difference" is $2(10)^2/20,000$ 0.010.

In the preceding discussion a single numerical example has been employed as being the most comprehensive illustration. However, all work has been checked by applying the same process to general terms. Similar results would be true for all possible numerical problems.

This article is submitted to readers with the trust that it will prove to be as helpful to some of them as it has been to the writer.

PLANNING THE INDUSTRIAL TOWN OF IROQUOIS FALLS, ONTARIO.

Contributed by A. P. Melton, Civil Engineer, Gary, Ind.

The prevailing method of laying out industrial towns in connection with new plants a few years ago was to plan and build the plant, plan and reserve ground for possible future extensions, reserve more ground for possible or impossible contingencies, reserve some more because it was too valuable for a town site and finally permit the use of a certain tract as a town site with various restrictions and reservations.

We all know this type of town—ugly rows of cheap unsanitary, unsightly houses built alike from one stock plan, a few dingy corner saloons and dingier stores, muddy streets, paper and garbage strewn alleys and a general air of neglect, gloom and poverty ever present. Those unfortunates to whom destiny has assigned such a place to be born and reared in, or as a habitation in later life, the effect of such depressing environment, continuously, with its lack of beauty, refinement, culture, healthful pleasure and ideals can but result in a lower moral and mental standard and consequently in a lower and less efficient physical capacity.

Within the last decade those at the head of great industrial enterprises have differentiated more and more between man and machine as applied to industry. Science, experience and human ingenuity can determine just what materials are necessary to build a certain machine to perform certain work, and can determine accurately just what fuel and other materials are necessary efficiently to operate the machine, likewise science and experience have determined what elements are necessary to support human life and furnish fuel as it were for the performance of physical tasks, but science does not know what life, the soul or the mind are; it can not isolate, dissect or examine them or prescribe a specific food for their development or maintenance, and without the full development of these elements no human being can be complete or efficient in any line of endeavor.

The writer believes that the providing of means, room, surroundings, beauty and as many suggestions as possible which may tend to influence the full development and contentment and happiness of the community is just as important a problem to the town site engineer as the proper design of street, sewer and water works improvements.

In planning the town of Iroquois Falls, Ontario, Mr. F. H. Anson, President of the Abitibi Power & Paper Co., Limited, and other officials of the company, took up the matter with the writer with as much earnestness and with as much regard for detail and careful selection of site as they did in the construction of their great paper and pulp mills at this place. The mills and town are situated on the Abitibi River some 400 miles north of Toronto and about 150 miles south of James Bay. The mills are abundantly supplied with water power by the falls in the Abitibi River at this point.

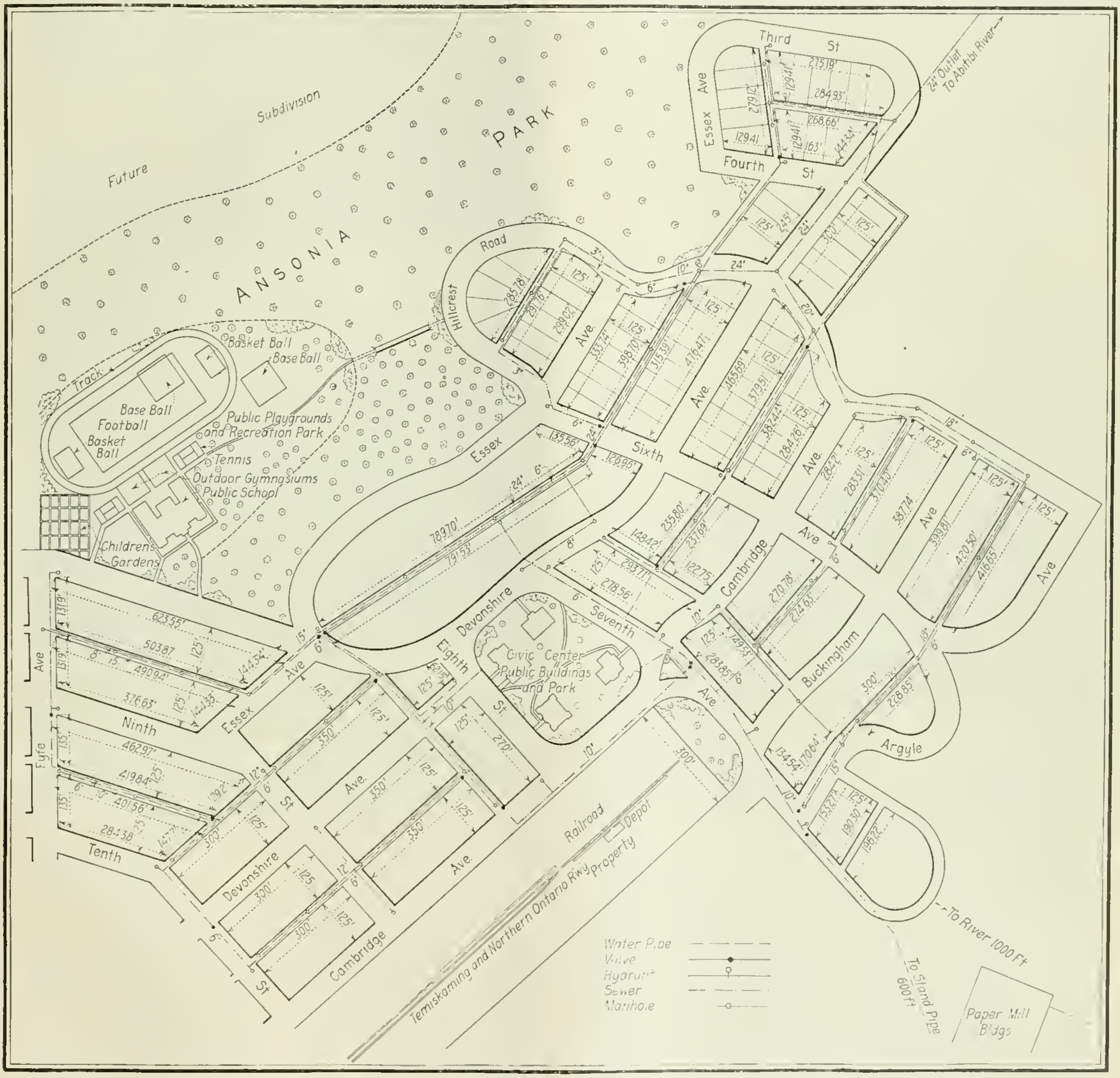
The town site is beautifully situated in a right angle bend of the river on a rolling plateau having an elevation of 125 to 150 ft. above the river, this plateau being indented at various places by short and deep ravines, with an occasional ravine extending back for half a mile or more from the river.

The gridiron system of laying out streets was followed in principle as being the most practical and economical method, however the topography of the site was such that it was advisable to curve a number of the streets to get economical grades and at the same time utilize the maximum amount of the plateau, resulting in a very graceful layout without departing greatly from the gridiron principle. All business lots were made 25 by 125 ft. in size and residence lots were in general 50 ft. in width and from 110 ft. to 150 ft. in length. About 80 acres were laid out in the first plat and provisions were made for future extensions of about 160 acres.

The controlling features of the first plat, which is described and illustrated in this article, are the railroad and the edges of the plateau. A number of rectangular blocks were laid out adjacent to the railroad for business purposes, a small park forming a sort of civic center and sufficient in size to contain all necessary public buildings was laid out adjacent to the railroad and business district with the idea that the better class of business buildings will face on this park, the bank, theater and hotel being included in this class. A small park is also provided at the end of the railroad which, with the larger park, furnishes a screen between the residence and business portions of the town. The arrangement of these details will give a very pleasing "First Impression" to passengers alighting from the trains. Another advantage lies in the fact that children would not pass through the business district on their way to school. Locations are suggested for churches which add to the harmony of the layout.

The school site shown contains about nine acres and it is intended that the school grounds shall be the public playgrounds and athletic park, for adults as well as children, also it is planned that the school gymnasia, and auditorium be open to the public at all times when not being used for school work. Part of the school grounds are set aside for children's gardens, the idea being to give the children actual experience in growing such products as may be propagated in that far north climate and at the same time foster an interest in agriculture. The writer could say a great deal about the school plant if space would permit, as this institution takes care of about one-fourth of the population for several months in the year and is worthy of considerable comment. The school grounds as shown on the plat merge into a large park which includes two branches of a deep ravine that form the boundaries of the school grounds proper.

In laying out the streets a drive named Hilcrest Road was laid out around the edge of the plateau, following as closely as possible a certain elevation, and laying out interior streets to approximate the usual gridiron system, most of them being curved to conform to the general direction of the contour lines, and wherever possible terminating all interior streets in the heads of the various ravines at the edge of the plateau thereby providing a useful and economical dumping space for dirt excavated out of the streets, and also enabling more ground to be utilized for building purposes. Grades were established so that the sidewalk would be slightly lower than the general property grade to provide proper slope from the house to the sidewalk, the average cut being from 1 to 2 ft. in the paved portion of the street, most of this excavated ma-



Plan of Iroquois Falls, Ontario.

terial being used in filling up the heads of ravines. The same irregularity in grades is practiced as in street lines, the grade lines following as closely as possible the contour of the ground and all changes in grade being connected by means of vertical curves consisting of a change of 1 per cent in grade for each 20 ft. of horizontal distance. It was attempted to keep all grades under 7 per cent, but one of 10 per cent was established for a short distance.

Nothing out of the ordinary was attempted in the way of improvements, all streets being of macadam with combined curb and gutters and 5 ft. cement walks, residence streets having a 22-ft. roadway between curbs and business streets 36 and 40 ft. Macadam, stone and gravel are obtainable within a short distance while any other material would have to be shipped 500 miles or more.

Sewers are all collected into one 24-in. outlet which discharges into the river below the town and all have more than ample fall. All sewers are to be constructed of vitrified tile.

The water supply is taken from the Abitibi River above the town and is treated by means of a Norwood Engineering Co. coagulating and pressure filter installation.

On account of the severe climate it is necessary to have at least 7 ft. cover over all water mains. The water in the river has the characteristic color due to vegetable matter common to all streams in this locality, but being in a virgin forest is polluted in no other manner and is perfectly pure after the filtering process.

The company furnishes electricity from its hydro-electric plant for domestic and street lighting. Sewers, water pipes and light poles are placed in alleys wherever practicable.

The soil is clay and is heavily timbered with spruce, balsam, tamarack, poplar and some birch.

The population of the town will probably never exceed 2,500 as not more than 500 operatives will be employed in the mill; however, a much larger force will be employed in the woods but will make their headquarters elsewhere.

LUMBER MAT BANK PROTECTION ON MISSISSIPPI RIVER IMPROVEMENTS.

Referring to shore protection mats of cull lumber as a substitute for brush mattress the engineer officer of the Rock Island District in Professional Memoirs gives the following comparisons:

The plain lumber mat, put together with nails and wire, was first employed in the division Wisconsin River to Le Claire. Its success was so great, being sufficiently strong for sinking without breaking and when sunk proving quite as serviceable as a brush mat, that it has been used since 1911 in the lower divisions and especially between Hannibal and the Missouri River. In these divisions, however, the width of mats has ranged from 20 to 40 ft., according to circumstances.

In five years there has been placed 77,092 lin. ft. of lumber apron mat (about 14½ miles) in which has been used for its fabrication 1,659,817 ft. B. M. of inch cull lumber. The lumber and rock has so varied in cost and the mats so much in width that no account has been kept of the saving, although it is known that in nearly every case the lumber mat has proved cheaper than the brush mat and equally satisfactory. In localities and at times when brush was cheap and lumber expensive, brush was still used.

Considerable thought and study have been given to the experience of the St. Louis district lumber and brush shore protection mats, with a view to determining the relative quantities of rock needed for sinking both brush and lumber mats, bearing in mind that a mat once down on the bottom is safe. Using the square (10 x 10 ft.) as the unit, we find rock needed for sinking plank mat .555 cu. yd. per square and for sinking brush mat 1.11 cu. yd. An application of these figures, tentative as yet, gives the following result, with brush at 24 ct. and rock at 85 ct. per cubic yard and lumber $12 per thousand feet board measure, all of which are average prices:

FOR BRUSH MAT 1,000 FT. LONG, 30 FT. WIDE (300 SQUARES).

Brush, 1,111 cu. yd. at 24 ct.	$266.64
Rock for sinking, 333 cu. yd. at 85 ct.	283.05
Towing brush, 1,110 cu. yd. at 4.2 ct.	46.62
Towing rock, 333 cu. yd. at 21 ct.	69.93
Labor constructing mat, approximate	56.00
Labor sinking mat, 333 cu. yd. at 4 ct.	13.32
Wire, 80 lb. at 3 ct.	2.40
Total	$737.96

FOR LUMBER MAT 1,000 FT. LONG, 30 FT. WIDE (300 SQUARES).

Lumber, 19,800 ft. board measure at $12 per M	$237.60
Rock for sinking, 166.5 cu. yd. at 85 ct.	141.52
Towing lumber, say	6.00
Towing rock, 166.5 cu. yd. at 21 ct.	34.97
Labor, constructing mat	35.00
Labor sinking mat, 166.5 cu. yd. rock at 4 ct.	6.66
Nails and wire	8.95
Total	$470.70

An indicated saving by use of lumber mat of $267.26, or 89 ct. per square. It is proposed to adopt this method and these quantities for a thorough trial, and although it may be found necessary to revise values and quantities.

PLACING ROCK FOR SHORE PROTECTION BY DERRICK BOAT.

Placing rock for bank protection on upper Mississippi River improvement work has ordinarily been done by wheeling from stone scows moored along shore. In 1915 and for part of another season in certain work a derrick boat has been substituted for wheeling and a reduction in cost obtained. As described by A. L. Richards, Assistant Engineer, in "Professional Memoirs," the derrick consisted of a creosoted fir hull 110x14x5 ft., having a set of 34-ft. spuds and carrying a derrick with a 40-ft. mast and a 66-ft. boom operated by a three-drum 40-h.p. American Hoist & Derrick Co. hoisting engine, No. 166, and a swinging engine No. 169. The equipment also comprised two 1¼-cu. yd. skips, a clam shell bucket for removing old dams and a drag line bucket for grading banks. The drag line bucket worked successfully, but the clam shell proved too slow for efficient work. The derrick boat crew consisted of an engineman, a stoker and a signal man; by moving the lever stand forward and raising it so that the engineman can see the work, the signal man will not be needed. The cost of placing rock by derrick in 10 cases in 1915 is given in Table I. Commenting on the work Mr. Richards says:

> The derrick can place the rock on the bank faster than seven or eight men can load the two available skips. Three skips and about twelve men—six to each of two skips loading at one time while the third was dumping its load upon the bank—would be a better arrangement. A skillful operator can so dump as to distribute the rock in a layer needing little further attention, thereby reducing the number of men required on the bank. It is also proposed to use skips holding about 2 cu. yd., which will reduce the cost per unit. With rock reasonably free from spalls, a capacity of 35 to 40 cu. yd. per hour may be expected.

TABLE I.—ROCKING BANK BY DERRICK, 1915. NEW WORK ON BANK OPPOSITE GRAFTON, ILL.

	No. of men.		Cost per cubic yard					
Time, hours.	Loading.	Placing.	Loading.	Placing.	Total.	Cubic yards.	Cu. yd. per man per hour.	Portion of bank rocked.
4	7	2	$0.092	$0.019	$0.111	104.9	3.75	From 8 feet above low water to top of 16-ft. bank.
5	7	2	.112	.023	.135	107.8	3.08	
3½	10	3	.105	.025	.130	105.6	3.02	
3½	10	3	.103	.024	.127	107.0	3.06	
4	10	3	.088	.021	.109	143.2	3.58	
3½	10	3	.083	.019	.102	133.8	3.82	
4	8	3	.091	.026	.117	116.5	3.64	
3½	12	3	.088	.018	.106	145.4	3.47	
3	12	3	.090	.018	.108	132.0	3.42	
6	6	1	.108	.012	.120	120.8	3.36	

> The average cost of unloading rock on the bank with derrick-boat during season of 1915 was as above stated, $0.115 per cubic yard. The average cost of unloading with wheelbarrows in 1913, under very favorable conditions, it being cool fall weather, was $0.163 per cubic yard. The difference between the two methods shows a cost saving of $0.048 per cubic yard in favor of the derrick-boat. Assuming a derrick-boat plant charge of $3 per day, this would increase the unloading cost by this method $0.012, making a total unloading cost of $0.135, which still shows a difference of $0.036 in favor of the derrick-boat. The average yardage per man per hour, unloading with wheelbarrows, is 1.9 cu. yd., while with the derrick-boat it is 3.4 cu. yd., which is 79 per cent more rock unloaded per man per hour in favor of the derrick-boat.

In comment on these remarks the district engineer considers that, including the first cost of $7,000 of the derrick boat, a plant charge of $6 per day would be more nearly correct than $3 per day.

Current Engineering Practice Briefly Recorded

STEAM SHOVEL GRADING ON RATTLE SNAKE POINT ROAD IN OREGON.

Contributed by N. J. Chapman, Chapman Construction Co., Klamath Falls, Oregon.

A notable example of road grading, using a steam shovel, is illustrated by the accompanying views. The work was in Klamath County, Oregon, overlooking Klamath Lake, and was part of a 9-mile road, about 7½ miles of which were light earthwork, which was performed with teams and scrapers. The remaining 1½ miles were steam shovel side hill cutting around Rattle Snake Point and having a grade of about 3 per cent. The cut was made with a side slope of 1 on 1½ and wide enough to give a 20-ft. roadway outside the ditch. This cutting gave a yardage per lineal foot of road of from 5 to 8½ cu. yd. The material consisted of loose boulders, which had slid down the mountain side, overlying in places cemented gravel, cinders, chalk rock and solid ledge. All had to be blasted.

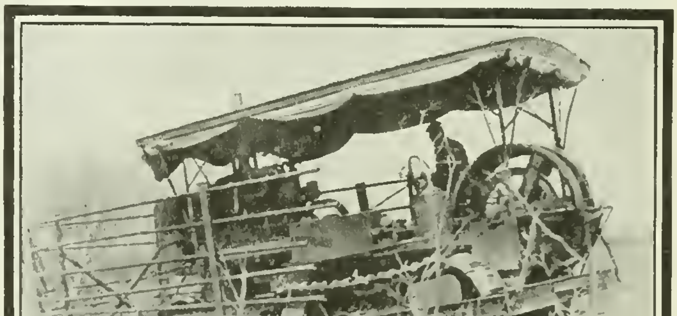
The general method of work was to blast and excavate with steam shovel, casting the spoil down hill to form embankment. A 4-in. duplex pump operated by a 6 h.p. Fairbanks-Morse gasoline engine was set 12 ft. above lake level. A 2½-in. suction pipe was used. The delivery pipe was 2 in. in diameter and 650 ft. long and delivered up hill to a tank located above all parts of the work. From this storage tank the water was piped to the steam shovel and camp. To provide the daily supply the pump had to be operated about one hour. For the drilling, a 10-h.p. Sullivan air compressor driven by a 6-h.p. Fairbanks-Morse gasoline engine was mounted on skids back of the shovel and the air pipe ahead to two Little Giant rock drills. One team could move the compresser plant ahead 1,000 ft. and set it up ready for work in 30 minutes.

The steam shovel was a No. 14B revolving Burgess. The crew working on and about the shovel consisted of an engineman, a fireman, a pitman and a wood and water man. The shovel graded 7,884 lin. ft. at an average rate of about 60 ft. per day. The total operating cost, including labor, oil, repairs, fuel and lights, but excluding interest, depreciation and overhead charges, was $6,480.90, or about 12 ct. per cubic yard. Finishing behind the shovel was done by hand and it usually took three men per day to finish up in good shape. The cost of finishing was 3 ct. per cubic yard, based on the total yardage handled by the shovel.

Blasting ahead of the shovel cost more than solid rock would have cost, because the drills could not be used in all material. In many places "coyote" holes 6 in. in diameter and 20 ft. into the bank had to be drilled by hand. Also care had to be exercised in blasting to protect the railway tracks downhill from the grading. The crew ahead of the shovel consisted of from 6 to 12 men, and one powerman, who did all the loading and firing. A 60-hole battery was used for firing. The blasting cost, including labor, powder, exploders and battery, $11,882.98 or about 22 ct. per cubic yard based on the total steam shovel yardage.

CLEARING BRUSH WITH A CATERPILLAR TRACTOR.

The illustration shows a caterpillar tractor fitted with a brush cutting device for clearing land for farming, irrigation, reservoir, road or other work requiring removal of not too large growths. With the equipment shown a swath 16 ft. wide was cleared at a rate of 2 miles per hour. The pointed framework attached to the front of the machine has at the bottom two long, sharp knives. These knives run close to the ground and cut the brush close to the surface while the frame above throws the cut brush aside in windrows. It is stated that saplings up to 8 in. in diameter have been cut. Another attachment, which can be used where grubbing needs to follow clearing, is the plow shown by the second illustration and first developed for grubbing grape vine roots by the Killefer Mfg.



Co., Los Angeles, for the Stanford Vina Ranch. As indicated the plow is simply a big U-forging which goes down any depth desired, from one-half an inch to 30 in. into the ground and cuts off the roots, the depth being regulated by a simple screw and handwheel. At 24 in. depth the plow has cut roots 8 in. in diameter. The puller weighs 7,000 lb. It is 15 ft. long, over all; 7 to 10 ft. high. The main members of the frame are 12-in. I-beams. In the bottom of the U-forging is a sharp-edged shoe or plate which cuts the main roots of the vines. Two wing plates are fastened to the upper half of the U to guide it centrally under the vines. The caterpillar tractor used was made by the Holt Manufacturing Co., Stockton, Cal.

LIDGERWOOD LEVEE BUILDING CABLEWAYS ON MISSISSIPPI RIVER IMPROVEMENT.

A taut line cableway of the Lidgerwood type, operating a scraper bucket excavator, was employed in 1915 in levee enlargement on the Mississippi River. As described by Major J. R. Slattery, Corps of Engineers, U. S. A., in "Professional Memoirs," the first cost of a machine of this type, erected and equipped, is about $45,000. It has a clear span of 662 ft. The towers are of steel, 85 and 45 ft. high, respectively, and support between them a 2¼-in. cable. On this cable travels a carriage which carries a 3-yd. drag-line bucket. The carriage is moved back and forth by means of an endless line, operated by one of the drums of the main engine. The bucket is loaded by means of a cable which leads from the front end of the bucket to another drum on the main engine, and is lifted by means of a cable which is attached to the bale of the bucket and runs thence around a sheave on the carriage, over a sheave at the top of the head tower, and thence to a third drum on the main engine.

A pull of 50,000 lbs. for loading the bucket is developed by means of a special engine, which operates a haul-down rope which runs from the drum of this engine around one sheave of a double tandem block (the second sheave of which rides on the drag or loading line), and thence to the frame of the tower.

The bucket is dumped at will by means of a haul-down rope which pulls down on the dumping line attached to the back of the bucket, and running thence to the conveying drum, thus accelerating the movement of the rear of the bucket relatively to that of the front end and consequently causing the back end of the bucket to lift, and the material to dump. This haul-down rope is operated by means of a piston and steam cylinder.

A special engine is provided on the head tower to move the same. The tail tower is moved by means of a friction drum operated by the conveying line.

Derricks were originally provided on both head and tail towers to pick up track from behind the machine. This method of handling proved satisfactory on the tail tower, three men being able to handle the track without difficulty. The long boom of the derrick on the head tower made this derrick unwieldy to handle by hand, and its use was therefore abandoned, and the track thereafter dragged forward by means of the moving engine.

The frictions and brakes are all operated by compressed air. The crew of this machine consists of: 1 foreman rigger; 1 operator; 1 rigger's helper; 1 engineman; 1 fireman; 1 signalman; 8 laborers (trackmen), 3 on tail tower and 5 on head tower; 3 laborers (dressing levee), and 3 teamsters (ploughing, dressing levee, and hauling supplies).

Table 1 gives the results of the season's (1915) work:

TABLE I.

Month.	Yardage placed during month.	Cost per cubic yard.	Yardage placed since work began.	Average cost per cubic yard.
April	5,211	$0.1850	5,211	$0.1850
May	13,239	.1386	18,450	.1518
June	20,050	.1548	38,500	.1534
July	23,850	.1126	62,350	.1378
August	19,050	.1490	81,400	.1404
September	2,600	.7047	84,000	.1579
October	22,800	.1041	106,800	.1464
November	28,500	.1108	135,300	.1389
December	18,600	.2253	153,900	.1494

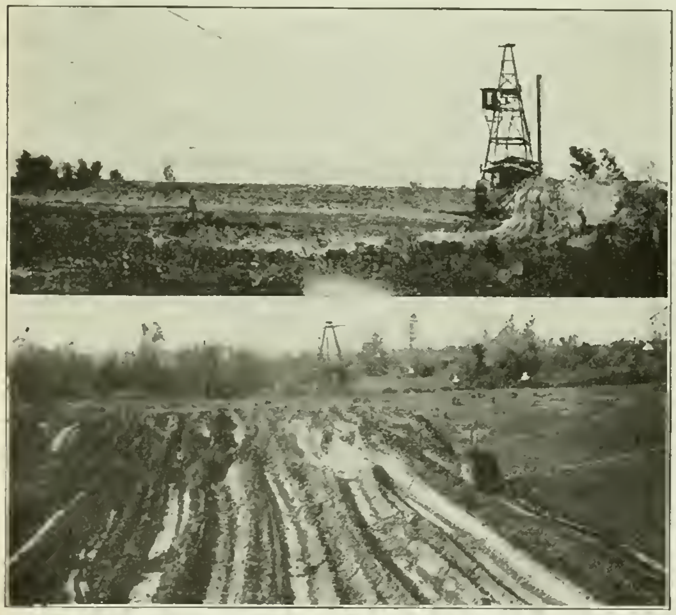
The very high costs of September were due to practically the entire month having been lost on account of high water, wet pits, and delays incident to renewing the main cable—the latter due purely to bad management. The high cost of December was due to a flood, and to the necessity of stopping work some days before actually drowned out, in order to prepare for a prolonged high water. Shortage of coal and the holiday season also cut down the output of this month. The past season was an exceptionally bad one for levee work, and progress was retarded throughout the season by wet pits. It is thought that with proper management this machine should be able to build or enlarge levees at field costs ranging from 8 to 14 ct. per cubic yard. As the material falls into place from heights varying from 10 to 40 ft. it is believed that this type of machine builds a particularly good levee.

DEVICE FOR COOLING COMPRESSED AIR USED IN TUNNEL CONSTRUCTION.

The Dorchester rapid transit railway tunnels under Fort Point Channel in Boston are being excavated by the shield method under a pressure of air from 18 to 25 lb. When the air pressure was first placed in the tunnels, says Mr. A. A. Cohill, engineer for P. McGovern Co., contractors, we did not consider it necessary to make any provisions for cooling the air, but we found this was a problem that would have to be reckoned with, and we were not very long installing after-coolers. The cooler we are using is about 3 ft. in diameter, and 12 ft. long, with about one hundred and twenty 1½-in. brass tubes through which harbor water is pumped. As the air leaves the compressor it passes into the after-cooler, where it is expanded and cooled and then carried on to the heading through an 8-in. steel pipe. At the discharge end of this pipe, the air is practically dry. We have experienced no trouble whatever from carbon dioxide. It is safe to say you will find the temperature of the air at the discharge end of the after-cooler about 15 degrees higher than the temperature of the water that is being used to cool it. For example, today we had a temperature of 187 degrees at the compressor end of the after-cooler, and a temperature of 65 degrees at the discharge end, with a harbor temperature of 50 degrees. The tunnel temperature was about 72. This difference of 7 degrees might be accounted for by friction produced in the pipe, as well as by a reducer that caused back pressure, and the fact that the temperature readings at the after-cooler were taken in the morning, and the tunnel temperature in the afternoon.

RECENT WORK WITH SLACKLINE CABLEWAY LEVEE BUILDING MACHINE.

On Mississippi River levee enlargement in Mississippi an improved form of slackline or tower cableway excavator installed by H. B. Blanks & Co. has been doing notable work. The original form of this machine was described in our issue of May 12, 1915. Later the manufacture was taken over by the Bucyrus Co., South Milwaukee, Wis., and the machine built for the Blanks company was greatly improved over the original. In operation one tower (the head tower, travels on the old levee banquette and the other tower, travels parallel and about 450 ft. away, the 450 ft. cableway between towers thus spanning the borrow pit. A drag line scraper traveling back and forth between towers scrapes successive loads from the borrow pit and deposits the material in the old levee. The two accompanying views explain the process: At the top is shown the head tower traveling on the levee top and the new material being deposited against the levee slope; at the bottom is shown the tail tower and the bucket taking its load from the borrow pit. The bucket used is 8 cu. yd. capacity. Working about half of October, 1915, the machine placed 10,340 cu. yd., in November it placed 31,077 cu. yd. and in December 28,083 cu. yd. About 1,800 cu. yd, per 100 ft. were required for the enlargement. The crew consisted of 2 foremen and riggers, 2 head tower operators, 1 tail tower operator, 1 oiler, 1 fireman, 10 laborers, truckmen and dressers, and 1 team and teamster. According to Mayor J. R. Slattery, corps of engineers, U. S. A., writing in "Professional Memoirs," this machine will build river side enlargement at a field cost of 8 to 12 ct. per cubic yard, exclusive of grubbing and clearing. Recently two machines still further improved to build land side enlargements and to widen banquette have been constructed.



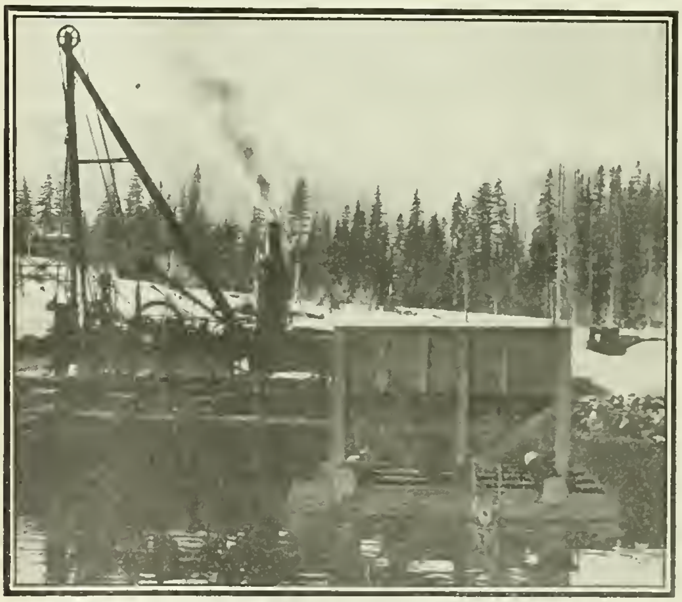
RAFTS FOR SUPPLYING A DIPPER DREDGE WITH COAL.

Contributed by R. E. Post, Superintendent of Construction.

In connection with the dredging work done by the U. S. Reclamation Service at Keechelus Dam, Washington, coal rafts were so designed that the coal did not have to be rehandled at the dredge as shown in the accompanying illustration.

Two rafts were provided, each consisting of a coal box built upon four fir logs 16 ft. long and 4 ft. in diameter well fastened together with drifted cross ties. The coal box was about 10 x 10 x 2 ft. deep and was built at such a height above the raft that when loaded the door of the box would drop down upon the dredge deck and form a level shoveling platform. The door was about 8 ft. long, hinged at the bottom and held closed by latches at the sides.

In operation the empty raft was taken away and the loaded one towed to the dredge. It was fastened at each corner with chains leading from small gas pipe winches placed on the deck of the dredge. When the chains were hooked to the raft the winches were wound up until the raft was in its proper place against the deck of the dredge which projected out about 3 ft. to receive it. Then the door latches were tripped and the coal was ready for use.



As will be seen from the illustration it was necessary to place the coal raft between the rear spud housing and the side of the dredge. This in turn governed the location of the boiler which was placed so that the fire door came opposite the door of the coal raft and about 6 ft. from it.

These rafts were not entirely stable as the center of gravity was above the center of buoyancy, but if loaded with reasonable care they did not tip enough to get them started over and in the two years they were in use only one load of coal was overturned.

METHOD OF QUARRYING A 225-TON GRANITE BLOCK.

One of the largest pieces of granite even quarried in this country is that used to form the basin of a large fountain on the estate of J. D. Rockefeller at Tarrytown, N. Y. This block of granite, as quarried, measured 22 ft. square by 5 ft. 3 in. thick and weighed approximately 450,000 lb. It was taken from the quarries of the J. J. Goss Corporation in Maine. The following description of the methods used in quarrying, transporting and finishing this large block of granite were taken from a paper by

J. J. Goss in the American Stone Trade: A peculiar advantage was enjoyed in executing this contract due to the fact that the distance from the quarry to tide water in Penobscot Bay is only 1,000 ft. and is down grade the entire distance. There was a ledge of granite in the quarry 10 ft. thick and of sufficient size to get out the rough block, which was done by putting in a lateral row of plugs and "feathers" entirely around the two exposed sides of the block at a distance of about 6 ft. down from the top ledge. In addition, three horizontal holes, 1¼ in. in diameter and 6 ft. deep, were drilled into both of the exposed sides of the ledge directly in line with the plug holes. Blasting powder was exploded in the six holes (three on each side), and the rough block was successfully split loose from the main ledge, although the bottom of the block was very uneven. By driving wedges in the crack split by blasting the block was raised high enough to take the lips of the various jacks, after which it was moved from its natural bed on iron rollers to a roadway built for this purpose. It was moved along this roadway about 600 ft. on about 70 spruce rollers, about 8 ft. long and from 10 to 12 in. in diameter, to a position on level ground suitable for working. Power was supplied by a portable engine, securely anchored.

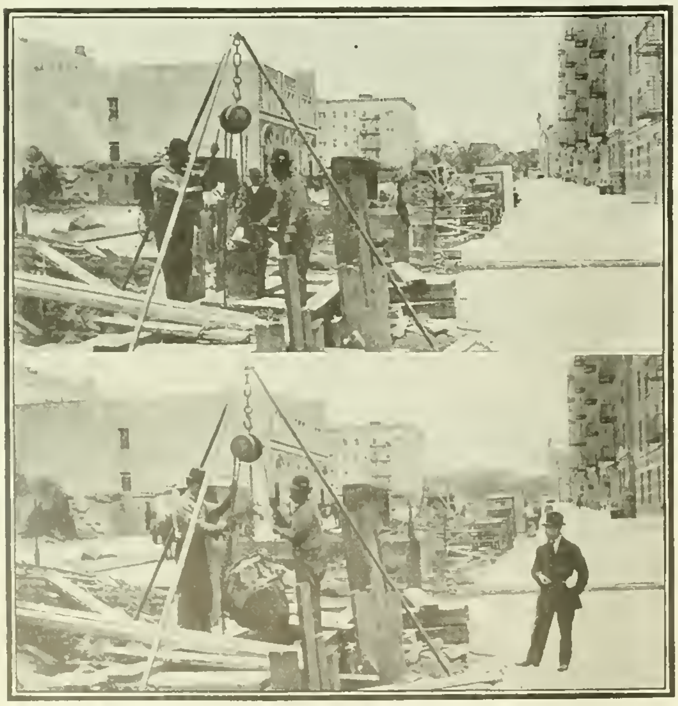
REMOVING ROCK FROM DEEP MANHOLE EXCAVATION.

Contributed by C. M. Hartley, Assistant Engineer, Empire City Subway Co., Ltd., New York City.

The troublesome problem of cheaply and efficiently mucking rock from deep telephone conduit manhole excavations has been solved by the Empire City Subway Co., Ltd., of New York city, in the following manner.

It was for many years the practice to remove this spoil by shoveling on to scaffolds, an expensive, and in many cases inefficient method, due to the many obstructions offered by pipes and mains crossing the openings. It is impracticable to install any sort of mechanical hoisting apparatus on this class of work, but we find that a combination of a steel tripod and chain hoist fills the bill.

The legs of the tripod are of 1½-in pipe, 12 ft. long, and pointed on the ends—with a short length of chain, a ring, and a hook, at the apex. The capacity of this tripod is figured as one ton, though we have never loaded one to any such figure. From the hook is suspended a Yale high-speed, ½-ton triplex block with special gearing, designed for rapid work in frequent lifting of light loads.



The buckets used in connection with this outfit are of steel, cylindrical in form, 13 in. in diameter, and 17 in. deep, holding 1.3 cu. ft. of material. These may seem small, and they are small, but as a general rule the conditions are such that it is impossible to use anything larger, and still get it in and out of the hole. We have, on occasion, used a flat wooden skip (3x2 ft.—capacity about 3 cu. ft.) in place of a bucket, where there was room to operate it efficiently.

Working in a manhole excavation 12 ft. deep, and using two buckets, we have operated at the rate of one emptied every three minutes, which gives 1 cu. yd. of rock per hour, with two men on the bottom, loosening the rock and loading the buckets, and two men on top, hoisting and emptying them.

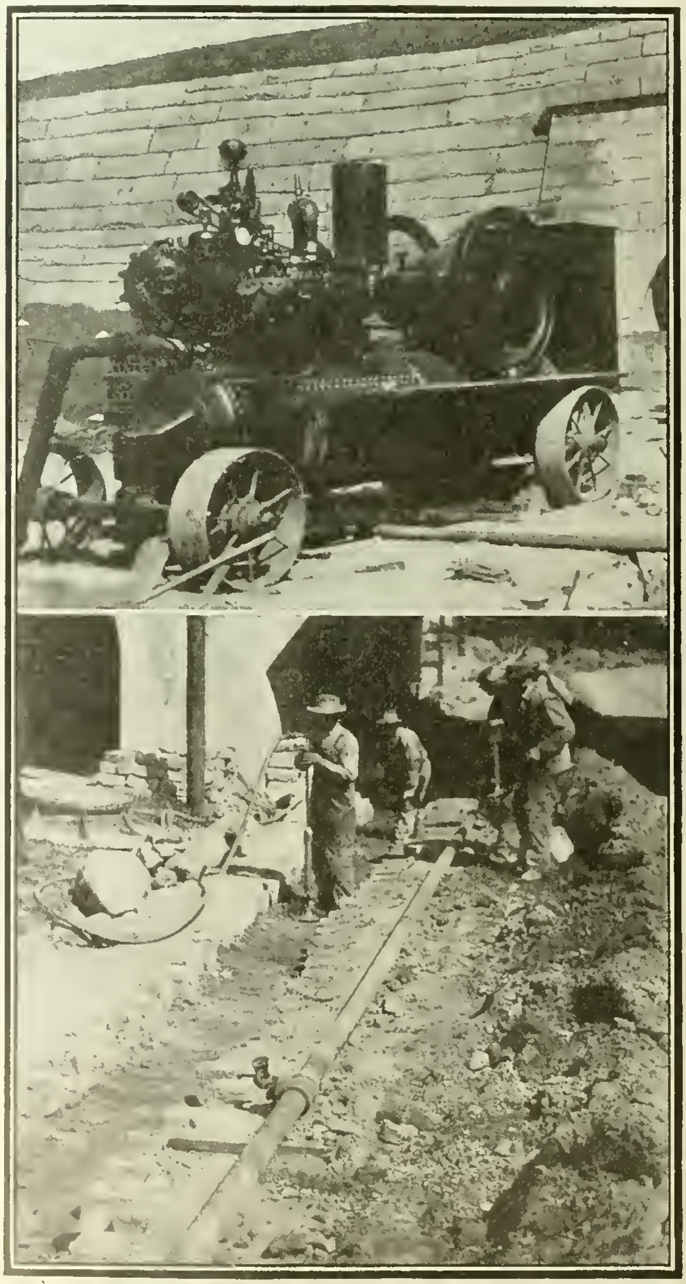
This installation is light, easily and quickly erected and taken down, and has also been found of great utility in removing "nigger-heads" and boulders from the trench.

The accompanying illustration shows this hoist in use on a manhole excavation at the intersection of 175th St. and Audubon Ave., New York city.

TRENCH TAMPING WITH PNEUMATIC RAMMERS.

Contributed by C. M. Hartley, Assistant Engineer, Empire City Subway Co., Ltd., New York City.

The most important point in the backfilling of trenches excavated in paved streets is the proper tamping of the material. Hand tamping is universally recognized as expensive, and, at the same time, quite often inefficient, and it is well, where practicable, to perform this work by mechanical means. Where compressed air is available, the Crown floor rammers (type 22-SR) manufactured by the Ingersoll-Rand Co. may be used to good advantage.



These machines, which consume 28 cu. ft. of free air per minute at a gage pressure of 100 lb. per square inch, are easily operated by one man, who does not need to be a skilled laborer, and they do not require any great amount of care to keep them in order, aside from cleaning and oiling.

Comparative tests of hand tamping and machine tamping have shown that the cost of the latter is about one-third the former, and, at the same time, the backfill is much better tamped.

We have backfilled a 50-ft. section of trench, 24 in. deep and 20 in. wide, containing 6.3 cu. yd., in one hour, with three men shoveling and six men tamping. This backfilling cost $1.80, or 28 ct. per cubic yard., and this ratio of tampers to shovelers insures good tamping. The tamping cost in this instance was 19 ct. per cubic yard.

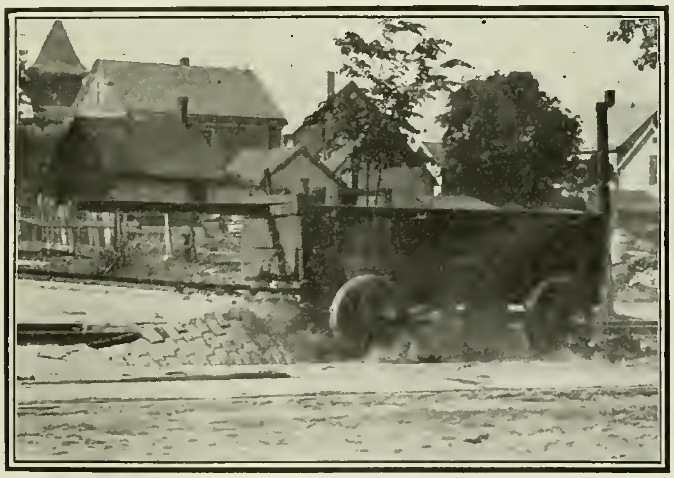
Another 50-ft. section 27-in. deep and 20-in. wide, containing 7.1 cu. yd., was backfilled and machine tamped in one hour, four men shoveling and one man running the rammer. I have never seen earth filling better compacted than it is by these tampers. The cost of this backfilling was 18 ct. per cubic yard, and of the tamping alone, 6.9 ct. per cubic yard.

Other tests have verified these figures, and we have found that, as a rule, the cost of tamping with these pneumatic rammers, on this class of work, is about 7 ct. per cubic yard.

The accompanying illustration shows one of these tampers in operation on Burnside Ave., East of University Ave., Borough of the Bronx, New York city.

REMOVING BLOCK PAVEMENT BETWEEN TRACK RAILS BY PLOWING.

For two years the Cleveland Ry. Co. has used a special plow for rooting up block pavement between rails whenever reconstruction of track was required. The plow first built was experimental and somewhat crude in detail; this original plow is the one illustrated. The view indicates the manner in which the plow works. Briefly, a cast steel spear-shaped blade with shallow mold boards is attached to the front end of a steel frame truck mounted on car wheels. The truck has a wooden body in which the necessary counter weighting load can be placed. In operation the truck is pulled by a work train and the plow blade loosens the pavement as illustrated. The designer of this plow is Mr. Chas. H. Clark, Engineer Maintenance of Way, Cleveland Ry. Co., who furnishes the following data: This pavement plow was designed by me and the Cleveland Railway Co. has had one of them in operation for the past two years, during which time we have made some very remarkable records; the following are only a few of the many instances in which the plow has worked and the time in which it has taken up the pavement:



4,500 ft. on Woodland Ave. in 28 minutes.
3.200 ft. on Woodland Ave. in 30 minutes.
1,500 ft. on E 55th St. in 12 minutes.
1,000 ft. on Euclid Ave. in front of Hotel Statler to E. 9th St. in 4 minutes.
1,475 ft. on Lorain Ave. in 13 minutes.

The plow is pulled by one of our work trains and on all occasions the labor required is as follows: A motorman and trolleyman on the work train and two men to follow the plow to connect the cable and lift the prow from the pavement in case of having to jump a manhole cover, etc. The maintenance of this plow amounts to very little and the cost of operation is insignificant. Considering this and the present state of the labor market, you can of course realize how much faster and how much cheaper the work can be done when the pavement can be taken up for four or five blocks in five or ten minutes. This has never before been done and we consider the plow a revelation in street railway work. I might mention further in connection with the operation of the plow that I am positive that any railroad which has but four miles of pavement to take up in one year could pay for the plow in that one operation. The saving in labor is enormous and the operation is very efficient. The Boston Elevated Ry. of Boston, Mass., has one of the plows in operation, as has also the International Railway Co. of Buffalo, and one is being completed for the Detroit United Railways of Detroit, Mich.

SOME UNIT COSTS ON STREET GRADING WITH A STEAM SHOVEL, IN MINNEAPOLIS, MINNESOTA.

Contributed by Fred T. Paul, Assistant Paving Engineer, Minneapolis, Minn.

The work under consideration was done by force account in 1915 under the City Engineer's Department, Mr. W. J. Walsh, Acting Engineer in charge. The material moved was a conglomerate with a medium fine sand predominating. The cut was from 2 to 15 ft. deep, 70 to 80 ft. wide, and about 3,500 ft. long. A Marion-Osgood No. 18, ¾-cu. yd. traction steam shovel placed the material in ordinary 1½ cu. yd. dump wagons, and these in turn deposited it in the fills on the street, making an average haul for the job of 1,000 ft.

The work was started June 12 and finished on Aug. 20, covering a period of 55 full working days of eight hours each, and five part days. On these part days, little, if any, dirt was moved, but the engineer, foreman, fireman, watchman and timekeeper received full time—while the laborers and teams were given only part time. A total of 21,500 cu. yd. of material were handled in the 55 full days, making an average day's output of 391 cu. yd. The maximum was reached during five days in the heaviest cut when 611 cu. yd. per day was moved.

The total material cost of the job was $199.56, distributed as follows:

27.45 tons of soft coal at $5.05 per ton	$ 138.62
50 gal. steam cylinder oil at $0.294 per gal	14.70
Blacksmith repairs	17.64
New shovel parts	.82
Miscellaneous, including waste, packing, hose, grease, etc.	27.78
	$ 199.56

The average daily payroll was as follows:

1 foreman at $4 per day	4.00
1 engineer at $6 per day	6.00
1 fireman at $2.50 per day	2.50
1-20th timekeeper at $4 per day	.20
1 watchman at $2.50 per day	2.50
2 laborers on dump at $2.50 per day each	5.00
2 laborers in pit at $2.50 per day each	5.00
1 laborer on coal and water at $2.50 per day	2.50
6 laborers straightening and leveling up at $2.50 per day each	15.00
7 teams on dump wagons at $5 per day each	35.00
Total average daily payroll	$ 77.70
Grand total payroll for sixty days	4,553.61
Total material as above	199.56
Interest and depreciation on plant	70.00
	$4,823.17

Distribution and Unit Costs.

	Amount.	Per cu. yd.
General—		
Foreman, 60 days at $4	$ 240.00	$0.01116
1-20th timekeeper, 60 days at 20 ct.	12.00	.00056
Total general	$ 252.00	$0.01172
Excavating and Placing Material in Wagons.		
Labor—		
Engineer, 60 days at $6	$ 360.00	$0.01674
Fireman, 60 days at $2.50	150.00	.00698
Watchman, 60 days at $2.50	150.00	.00698
2 pit laborers, 58 days at $5	290.00	.01349
Laborer on coal and water, 58¼ days at $2.50	145.61	.00676
6 laborers on cleanup, 58 days at $15	870.00	.04047
Total labor	$1,965.61	$0.09142
Material and supplies as above	199.56	.00928
Interest and depreciation on plant, 10½ per cent on $4,000 for 60 days	70.00	.00325
	$2,235.17	$0.10395

Hauling, Including Placing in Dump.

7 teams, 58½ days at $35	$2,046.00	$0.09516
2 laborers, 58 days at $5	290.00	.01349
	$2,336.00	$0.10865
Grand totals	$4,823.17	$0.22432

Based on the total cost of moving 21,500 cu. yd. an average distance of 1,000 ft., the cost per cubic yard hauled 100 ft. would be .0221. However, the actual hauling cost per cubic yard per 100 ft. was only .0108.

PERSONALS.

Mr. E. R. Wells, Jr., has begun his duties as City Manager of San Angelo, Texas.

Mr. O. A. Geirlich has been appointed city engineer of El Monte, Cal., succeeding Mr. Robert L. Wood, who resigned recently.

Mr. W. W. White, formerly engineer of the Western Hospital for the Insane, has been appointed superintendent of the Municipal Light Plant of Bolivar, Tenn.

Mr. H. O. Kelley, heretofore assistant engineer of the Evansville & Indianapolis Railroad, has been appointed division engineer, with headquarters at Terre Haute, Ind.

Mr. George Bowen has been appointed head of the Water Department of Aberdeen, Wash., succeeding Mr. E. A. Lindstrom, who has filled that position for the past two years.

Mr. Gustav J. Requardt, formerly assistant engineer for the Sewerage Commission of Baltimore, Md., has been appointed head of the new department of franchises and privileges of that city.

Mr. W. W. Judson, heretofore in the engineering office of the Northern Pacific Ry., at Centralia, Wash., has been promoted and will have charge of the construction work on the Grays Harbor Branch.

Mr. William Yohe, heretofore instrument man in the office of the City Engineer of Spokane, Wash., has been appointed field engineer and will supervise the grade separation work of the Northern Pacific Ry. in Spokane.

Mr. J. E. Ellms, Cincinnati, O., has been appointed temporary superintendent of the filtration plant at Cleveland, O. He will devote half his time to the Cleveland plant and the remainder to the plant at Cincinnati, O.

Mr. Karl C. Kastberg, formerly head of the engineering and water departments of Boone, Iowa, has been appointed city engineer of Des Moines, Iowa. Mr. Robert McCormick succeeded Mr. Kastberg as city engineer of Boone.

Messrs. M. E. Buck, Stephen P. Hogan and Henry F. Kroyer have organized the Montana Power Construction Co., of Anaconda, Mont., and will engage in a general contracting business, specializing in the building of dams, reservoirs, ditches, flumes, etc.

Mr. Robert T. Rumbold, for the past ten years with the Baltimore Sewerage Commission of Baltimore, Md., severed his connection with the Commission on May 31, due to the completion of the $23,000,000 sewerage system. Mr. Rumbold was the assistant engineer in charge of the construction of the interceptors along the water front, the tunnel construction in the center of the city and the development of the annex.

Mr. George A. Harwood, Chief Engineer Electric Zone Improvements of the New York Central Railroad, has been appointed Engineering Assistant to the Vice-President in charge of operation, with headquarters in New York City. Mr. Harwood is a graduate of Tufts College, class of '98. He entered the employ of the New York Central & Hudson River Railroad in 1900 as a draftsman. He later was special assistant to the designing engineer, and then engineer of grade crossing elimination for the line east of Buffalo. He became assistant terminal engineer on the new Grand Central terminal in New York City in 1905, and in 1906 was promoted to terminal engineer, and later in the same year to chief engineer of electric zone improvements.

Mr. I. Lamont Hughes, assistant general superintendent of the Youngstown (Ohio) District of the Carnegie Steel Co., has been appointed general superintendent of the Canadian Steel Corp., Ltd., at Ojibway, Ont., where a $20,000,000 plant will be erected. Mr. Hughes will supervise the construction of the new work and after their completion will be in charge of operation. Mr. Hughes began work in 1897 in the Union Steel Co., which afterward became a part of the American Steel & Wire Co. In 1905 he came to Youngstown as engineer for the Youngstown district bar mills, which comprised the Upper and Lower Union Mills, of Youngstown, the Girard Mills, the Warren Mills and the Greenville Mills. He worked here under M. E. Coombs, who was general superintendent of the district. Upon the retirement of Mr. Coombs in March, 1906, F. B. Baugh was made general superintendent of the district bar mills and Mr. Hughes became assistant superintendent. Thomas McDonald was appointed general superintendent in January 1907 and all of the Carnegie Steel works in Youngstown district were brought under one management. Mr. Baugh was made superintendent of the bar mill department and Mr. Hughes was appointed assistant superintendent of the bar mills. Upon the death of Mr. Baugh in March, 1911, Mr. Hughes succeeded him as superintendent.

Mr E. J. Pearson, at present vice-president of the Texas & Pacific Railway, has been appointed vice-president of the New York, New Haven & Hartford Railroad, with headquarters in Boston, Mass. He will have charge of all matters relating to construction, operation and maintenance. Mr. Pearson was graduated from the civil engineering department of Cornell University in 1883. His first employment was with the Northern Pacific Railway. He was assistant engineer two years, engineering supervisor four years, division engineer two years, principal assistant engineer at Chicago two years. In this office he had entire charge of the building of the Wisconsin Central terminal, which at that time was leased to the Northern Pacific. Then he was division superintendent on three different divisions, covering a space of eight years, assistant general superintendent for two years and chief engineer for two years. He then went with the Chicago, Milwaukee & St. Paul Railroad and was in charge of building the Puget Sound extension of the St. Paul Road. He was vice-president of the Missouri Pacific system under Mr. Bush, and was in charge of maintenance, operation and construction and did much work in rebuilding and developing the line and in introducing economical operating methods. He occupied this office four years. He had been vice-president in charge of the Texas & Pacific and all its departments, with headquarters at New Orleans, for one year.

OBITUARY.

Oliver O. Smith, a member of the firm of Smith & Keffer, architects, Des Moines, Ia., died May 28 at his home in that city of heart trouble.

Chester B. Albree, founder and president of the Chester B. Albree Iron Works, died May 27 at his home in Pittsburgh, Pa. He was a graduate of Worcester Polytechnic Institute. Mr. Albree was an inventor and manufacturer of machinery and mechanical devices some of which are in wide use in this country. He was a past president of the Engineers' Society of Western Pennsylvania.

John Brady, one of the pioneer steel bridge builders, died June 3 at his home, 4905 Vincennes Ave., Chicago, Ill., aged 81 years. Mr. Brady superintended the erection of many of the earlier bridges in Illinois and other states.

James J. Hill, railroad builder, financier and developer of the great Northwest, died May 29 at his home in St. Paul, Minn. He was born in 1838 in a back woods farm in the vicinity of Rockwood in the Province of Ontario, Canada. He came to the United States in 1856 and located at St. Paul, Minn., at that time a frontier town of 5,000 inhabitants. His first position was as stevedore and clerk at a salary of 50 cents per day. For the next 15 years he was in the employ of various river transportation companies. In 1869 he entered into a partnership under the firm name of Hill, Griggs & Co., and engaged in the fuel business. The company brought in the first coal ever used in St. Paul. In 1870 Hill embarked in his first of three ventures that later made him famous, by establishing the Red River Transportation Co., operating boats on the Red River of the north, connecting at end of the St. Paul & Pacific Ry., and running to the city of Winnipeg. The next year he effected a consolidation with the competing boat line owned by Norman W. Kittson. A few years later he and a syndicate composed of Sir Donald A. Smith, George Stephen and Kittson acquired the Minnesota & Pacific Ry. This railway had gone into the hands of a receiver in 1873. In the meanwhile Hill, who had disposed of all his other interests and acquired thereby about $100,000, and his associates had purchased the securities of the company at a very low rate. They were therefore in a position to bid in the property when the mortgage was foreclosed. The St. Paul, Minnesota & Manitoba Ry. was formed to operate the road, with Hill as general manager. When the new company took control there were 437 miles of track, and extensions immediately made amounted to 220 miles, giving a total mileage of 657. This was capitalized at $31,000,000. At the end of the first year the equipment consisted of 65 locomotives, 69 passenger, baggage and express cars, and 1,523 freight and work cars of all sorts. In 1883 Mr. Hill was elected president of the railway and he began its extension to the Pacific Coast. Ten years later the Great Northern Ry. extending from Duluth to the Ocean, was formally opened. With the completion of an independent line to the Pacific Coast Hill began to extend the system. He built numerous feeders throughout the great grain belt of the Northwest, he organized a steamship line for the commercial invasion of China and Japan, and he established a fleet of steamers plying between Buffalo and Duluth, giving him an outlet to the Atlantic Coast. When he retired in 1907, the "streak of rust" he had bought 30 years before had expanded to more than 6,000 miles.

NEW CATALOGS.

Du Pont Products.—"Fabricord"; 5x8 in.; 112 pp. E. I. Du Pont de Nemours & Co., Wilmington, Del.

Lists and explains the products manufactured by this company. No less than 251 distinct commodities are made by this company.

Kahn Pressed Steel Construction.—8½x11 in.; 24 pp. Trussed Concrete Steel Co., Youngstown, O.

This publication describes the use of Kahn pressed steel joists and studs with hy-rib in building construction. It contains many new features and much useful information. Descriptions are given of an important type of fireproof floor and of the use of material in partitions and shearing walls. The catalogue also gives tables for carrying capacity, tests and specifications covering floors, partitions roofs, ceilings, etc.

Industrial Locomotives.—Paper; 9¼x6¼ in.; 24 pp. Bell Locomotive Works, Inc., 32 Church St., New York City.

This catalogue describes the general type of industrial steam locomotives built under the "Bell" patents. This one general type is constructed in three sizes, 3, 4 and 5 tons in weight. The standard type burns fuel oil, but gasoline burners can be supplied for special cases. No licensed engineer is required to operate these locomotives. Construction views of the Catskill aqueduct and the New York subways on which these locomotives were used are shown.

Surveying Instruments.—Paper; 6x9 in.; 125 pp. Heller & Brightly, Philadelphia, Pa.

Describes and illustrates the various types of instruments manufactured by this firm, which has specialized for half a century in the making of high grade transits and levels. The catalogue contains much information of interest to every user of surveying instruments. The testimonial letters not only cite severe tests to which the instruments have been subjected, but also give interesting suggestions on methods by which difficult problems were handled. The instruments are described in detail and specifications and prices are noted.

INDUSTRIAL NOTES.

The American Manganese Steel Co., Chicago, Ill., has purchased the plant of the Brylgon Steel Casting Co., at New Castle, Del., and is converting it into a manganese steel foundry of the latest and most efficient type. The American Manganese Co. now has two plants at New Castle and one at Chicago Heights, Ill.

Richard Martens, vice president and managing director of the shipping and engineering firm of R. Martens & Co., Inc., sailed May 15 on the Anchor liner California for Petrograd. During his six months' stay in America he has completed the organization of his American company, has studied closely every phase of the manufacturing situation and has addressed gatherings of prominent merchants and manufacturers in the largest trade centers. A corps of American engineers, experts in their particular lines, will join Mr. Martens in Petrograd this month for a conference with Russian engineering specialists after which they will tour Russia and ascertain in what form consumers will be able to use American products. At the conclusion of the conference the American engineers will return and report to manufacturers here what should be done in order that American products may be introduced in Russia. These American engineers, during the past six months have visited the most important factories here and have prepared detailed reports of just what American manufacturers are now ready to sell.

Stanley H. Rose, until recently in charge of the New York office of the Bureau of Foreign and Domestic Commerce of the Department of Commerce, has been engaged by The Barber Asphalt Paving Co. to direct its foreign trade department. Prior to his appointment as commercial agent of the Bureau Mr. Rose had had an extensive business experience in the larger part of Europe, Australia, New Zealand, India and Egypt, and has also held important posts with American and European firms engaged in foreign trade. He is considered an expert in foreign tariffs, trade regulations and shipping. As special agent of the Bureau of Foreign and Domestic Commerce, Mr. Rose has just completed a tour of more than fifty cities of the Middle West, South and Southwest, acquainting manufacturers with foreign trade opportunities and advising commercial organizations as to the best methods of promoting export trade. Mr. Rose was educated in London, Berlin, Paris and Brussels, and speaks most of the modern languages. The Barber Company's export trade is paving materials, roofing and other asphaltic products will hereafter be in Mr. Rose's charge, with headquarters in Philadelphia and New York.

Engineering and Contracting

H. P. Gillette, *President and Editor*

Volume XLV. CHICAGO, ILL., JUNE 14, 1916. Number 24.

Twenty-Five Dollars Monthly in Bonuses

First $12 **Second $8** **Third $5**

¶ Short stories containing usable suggestions are wanted for our department entitled *Current Engineering Practice Briefly Recorded.* (See this issue.)

¶ The character of article wanted is a plain, practical description of some simple and efficient structural detail or construction method, device or tool. Give costs if possible; provide sketches*, prints or photographs if practicable.

¶ *For all articles* published payment will be made at space rates.

¶ In addition, for the three articles ranking, in the opinion of the judges, first, second and third in order of merit, there will be awarded the bonuses stated above.

Instructions

(1) Articles must not exceed 1000 words.

(2) As many articles as desired may be submitted by the same person.

(3) Awards will be to articles, not to persons, so it may happen that one person will receive all three bonuses.

(4) Contributors need not be subscribers.

(5) Literary excellence will not determine merit.

(6) Name, position or rank will not influence awards.

(7) Contest for June closes July 15.

(8) Awards announced July 25.

* Rough free-hand sketches that convey the principle will suffice. They can be perfected by our drafting department.

Get Busy and Get a Bonus

AWARD OF BONUSES.

The awards of our monthly bonuses for May have been made as follows: First, $12, to C. M. Hartley, of New York, N. Y., for article entitled "Construction of an Electrical Subway Crossing a Highway Bridge"; second, $8, to W. D. Jones, of Los Angeles, Cal., for article entitled "Hoist Used on Seven-Story Concrete Warehouse, Los Angeles Harbor, California"; third, $5, to J. C. Worrel, Excelsior, Minn., for article entitled "Portable Shacks for Small Contract Work." The judges announce regret that there were not more prizes to award, stating that choice was difficult among so many articles, all meritorious to an unusual degree.

The publishers, as announced above, continue the offer of special bonuses for articles contributed between June 7 and July 12. They also wish to emphasize that all articles contributed, whether or not they are awarded a bonus by the judges, will be paid for at regular space rates. The work of preparing such contributions is, therefore, not entirely without monetary recompense under any condition. We shall hope to see an even more active contest in the month ending July 12.

JAMES J. HILL, RAILROAD PRESIDENT, AND A. M. WELLINGTON, RAILROAD LOCATOR.

We couple the names of "the greatest railway manager" with the name of "the greatest railway economist," the one known to all Americans, the other known only to civil engineers and students of railway economics. We couple these names because we believe there is a profound lesson to be drawn from the careers of these two men of genius, particularly when their achievements are contrasted.

Speaking editorially the "Railway Age Gazette" says:

> Mr. Hill was not only the "empire builder of the Northwest," but he was one of the very greatest railway managers that ever lived—in some important ways the greatest. He was the leading advocate, and may be said to have originated, the "tonnage" system of handling freight, which, expressed in other terms, is the system of handling it in the largest practicable train loads. He always maintained that his principles of railway operation were very simple. He said that a railway manufactured train miles, the number of which determined its expenses, and sold ton miles, the number of them it sold determining its earnings. Therefore, the fewer train miles it made, and the more ton miles sold, the more net money it would earn. The conclusion from this reasoning was, of course, that the more tons there were moved per train the more prosperous the railway would be—provided, of course, its economies of operation were not absorbed by increases of unit costs or reductions of rates. Within certain limits this philosophy of transportation has been proved by experience on American railways, and nowhere more notably than on the lines immediately dominated by Mr. Hill, to be sound. He largely increased the economy of operation and the earning capacity of every railway which he controlled.

The economic principle that a railway manufactures train-miles and sells ton-miles was, we believe, first given published expression in Wellington's "Economic Theory of Railway Location," long before Hill is credited with having begun to apply it. Prior to Wellington other civil engineers, notably on the Pennsylvania Railroad, had seen the principle and had applied it, but had not undertaken the task of teaching it to the rest of the railway world.

With transcendent talent as a teacher of economics, Wellington began editorially to blaze the economic trail that so many others—James J. Hill included—were ultimately to follow. It matters little that prior to Wellington other engineers had gone the same route. They left no blazings for the guidance of others; Wellington did. Finally he did more than blaze a trail; he hewed a veritable highway—his great treatise on railway economics—which thereafter none could by any chance fail to see, and, seeing, follow.

Harriman's and Hill's engineers alike have expressed their indebtedness to Wellington, the pioneer philosopher of rail transportation economics. Indeed no thoroughly candid and complete acknowledgment of intellectual debts in the railway field is possible without mention of Wellington's name. We therefore feel some resentment that one of the "principles" that Wellington did most to establish is so often spoken of as Hill's own discovery.

Wellington was essentially a philosopher and teacher. Hill was essentially a promoter and manager. The one dealt mainly with data, the other with men. Not that Hill was weak on statistics; quite the contrary. But he used data mainly as means of impressing capitalists and the investing public. The editor recalls hearing a speech by Hill before a chamber of commerce in a western city in 1892. Almost every bolt from his tongue was barbed with figures. He fairly shot the air full of detailed quantities and costs relating to transportation and commerce. His memory for details was prodigious, and his faculty for making it seem more astonishing than it was

was even more noteworthy. At the conclusion of an hour's address, the audience buzzed its amazement and admiration, man to man. They left the hall and stopped again to talk in groups about Hill and what he was about to do with his road to Puget Sound, his maximum 2 per cent grades, his proposed 40 ct. rate on lumber, his visions of Oriental traffic, his graphic painting of "the great—yes, the imperial city that yours is destined to become."

Hill was then 53 years old, just turning gray, impressive in figure and gesture, dominating in appearance and speech, sure of himself—sure as every prophet must be if conviction is to hang upon his words.

The editor recalls that even then he recognized in Hill's "principles" of railway economics most of the generalizations that Wellington had formulated. But of Wellington, or of Stevens, or of any other engineer, Hill said nothing. It was not until many years later, when the editor was engaged in appraising the "Hill roads" in Washington that Hill's opinion of engineers was learned. He regarded engineers in general as lacking in inventiveness and initiative—tools fit to perform in a mechanical manner. Perhaps that was his opinion of all classes of men, and perhaps it is an opinion well founded as to men in general, but certainly it led Hill to profit less from the advice of competent engineers than would seem credible in so great a man as he. His very strength, his self-assurance and magnetism, often became a source of weakness. If an engineer of dominating character undertook to teach Hill what to do, he "lasted" a very short time. If an engineer, or any high employe, failed to live up measurably close to Hill's standard of efficiency, he "lasted" even a shorter time. So, between being too strong a character and not being strong enough, every employe who came in direct contact with Hill stood an excellent chance of suffering official electrocution. Nevertheless, even those whose parting brought nought of "sweet sorrow" were compelled not only to acknowledge the greatness of the man, but to claim that his training had been good for them even when bitter.

Hill, as we have said, was essentially a leader of men and not a promulgator of ideas. Wellington was essentially a student and a teacher, probably just as great mentally as Hill, but along lines of greatness that seldom lead to enormous wealth or loud public acclaim. May we not without profit speculate upon what each of these two geniuses might have taught one another had they come into friendly contact? Hill, it is true, learned not a little directly from Wellington's book or from engineers who knew its contents, but consider how much more he might have absorbed from Wellington himself. The spirit has a fire of its own that no paper or parchment can fully imitate.

From Wellington doubtless Hill would have formed a higher opinion of "theorists," for here was a man of vision like himself, and a man gifted with even greater powers of clear and forceful expression. He would have learned, for one thing, that detail unit costs of construction are greatly to be desired as a means toward securing economy. This Hill certainly did not realize, for the editor found (in 1906-7) the engineering and accounting records of the Great Northern Ry. singularly deficient in this respect. For example, it was known that the Cascade Tunnel has cost about $180 per foot, but no one knew how much of this cost related to lining and how much to excavation. And had it been known to Hill what the excavation was costing per unit, he would have speedily stopped the day labor work. The excavation of that great tunnel cost 50 per cent more per lineal foot than it need have cost by contract, or than similar work did cost the Northern Pacific for its parallel tunnel through the same range.

In spite of his great fondness for quoting costs, Hill was not a cost analyst at all comparable with Wellington. We therefore believe that personal contact with Wellington would have opened Hill's eyes as they never were opened to the full possibilities of unit cost analysis.

It takes a deep-seated confidence in engineers to do what the Chicago, Milwaukee & Puget Sound Ry. has just done—supplant steam with electric locomotives on several mountain divisions. Hill, in spite of his foresight, lacked that sort of confidence. Wellington possessed it. An engineer himself, an inventor himself, he could and did see engineering possibilities beyond the range of Hill's eyes. Yet had Hill suffered himself to come under the spell of Wellington's magic, his eyes would have seen greater visions. May he not have had in mind some such thought when he recently said he regretted not having aimed at higher achievement.

Wellington could scarcely have failed to enrich his own mind by association with James J. Hill. Perhaps he would have seen that a great engineer may also be a great financier. Fired by Hill's example, he might have said to himself: I know all that Hill knows, and more, about the principles of railway economics. I can tell it, too, in quite as convincing a manner. I have visions as vast and as practicable as his. Why, then, must I wait for him or anyone to employ me to execute some plan? I will go out among men of means and make them dream my dreams. I, too, will be an empire builder.

But Wellington, unfortunately for mankind, lived a generation too soon. In his time engineering was regarded as sufficient unto itself. It was considered almost unprofessional to be a manager instead of a designer; and to be a promoter, even of a sound engineering project, carried with it more of disrepute among engineers than the word promoter still bears. Yet Wellington did a great deal himself toward destroying the ancient and narrow conception of what constitutes engineering. In his great book he repeatedly points out that a study of revenue is more important than a study of construction and operating costs. His is the rule that a well located railway should pass through the centers of the productive districts that it serves. He was the first engineering writer to give adequate attention to the revenue derivable from the plant. He sought to solve not merely for minimum cost but for maximum profit, and by that forward step he pushed engineering into a newer and broader field. He helped to commercialize it. Still he fell short of a full achievement.

Someone has said of inventors that it is amazing how frequently they fail to carry their devices to a greater perfection. It is as if, wearied by the toil of climbing a high mountain, the climber sinks to rest just short of the peak.

Wellington did a prodigious amount of work, and most of it without mechanical aids. In his preface he speaks sadly of not having known of the existence of the Thatcher cylindrical slide rule in time to save himself a vast amount of calculation. Perhaps one of the things that Hill's methods would have taught him would have been the wisdom of enlisting the services of other men.

Wellington, in short, was a one-man-power man. Hill seemed to be a ten-thousand-man-power man, because he had learned how to enlist the capital that gives command of men. Both were of equal native ability, as far as abilities exercised so differently can be judged. The promoter who fails to see the ability in our Wellingtons—our great engineers—errs quite as much as the engineer who fails to profit by the study of the methods of our Hills—our great promoters.

THE ARTICLE WHICH REVIEWS AND SUMMARIZES PRACTICE.

Catering to a survey party on which the editor worked many years ago was a colored cook. This cook on occasion produced from his pots a stew found exceptionally delectable by the younger members working all day in the open. Asked once how he made this stew the cook replied: "Well, suh, ah looks ovah what ah has and takes suthin o' this and suthin o' that and makes a judicial mixtry." There come to all editors of any extended experience many opinions from engineers as to the character of articles that an engineering journal should publish. Short articles, long articles, news articles, general articles, detail articles, pictorial articles, reportorial articles, statistical articles, analytical articles, synthetical articles, mathematical articles, articles which review and summarize practice are each considered preferable by someone. What, under the circumstances, should be the decision? The obvious answer is: A judicious mixture.

In another column there is published an article that reviews and summarizes practice in measuring flowing water. It is an article of a kind more rarely seen now than it was a dozen years ago. Its present comparative rarity is very largely due to the mistaken notion that the engineer who wants a review and summary of practice in any detail of engineering work goes to the library shelves for his information. This is a mistaken notion, first, because access to libraries is not had at all times when information is required, and, second, because review and summary are tasks requiring time and effort beyond what the busy engineer can afford except in important instances. Considering the article just referred to, it is evident that the accomplishment of an equally good review and summary of practice in measuring flowing water by an engineer not already well informed would mean many hours of search and access to an unusually well supplied library on hydraulics.

The purpose here in signalizing this fact is twofold. It is, first, to demonstrate the utility of articles of the character exemplified; it is, second, to secure to the compilers of such articles just credit for their labors. It is too much the practice to regard compilation as menial work. Invention—creation—of a new engineering process or operation is notable service. Perhaps it alone deserves credit as master work. But the man who reviews and summarizes these labors and presents them in a book or an article is performing a service only slightly less important to engineering progress.

EDITORIAL PARAGRAPHS.

Three twin-tube tunnels under the East River at New York City and enough other subway contracts to make up a total of $28,000,000 worth of work is the record of the contracting firm of Flinn-O'Rourke Co. The firm expects to have 20 tunneling shields at work this summer. If we are not greatly mistaken this is the tunnel contracting record.

Feldspar is the most common of all minerals. Engineers know it in practice generally only as a constituent of granite. A 200-page bulletin just issued by the Bureau of Mines tells us, however, that next to its use in pottery manufacture its greatest use is in the manufacture of roofing of the kinds most commonly used by engineers.

Sawdust, shavings, edgings and slabs sufficient to fill a box covering a 40-acre lot and a quarter of a mile high are produced each year by the saw mills of the United States. Some means of general utilization of this material now largely wasted is sought by the United States Forest Service.

"Advertise honestly," urges the Association of National Advertisers in resolutions adopted at their semi-annual meeting last month. The advice is excellent. The makers of materials and machines used in engineering construction, we are pleased in believing, do less misleading advertising than almost any other class of persons who use the public prints to make known their wares, but the caution comes with harm to no one.

Portland cement mills in 1915 produced 2.6 per cent less cement than in 1914, but they shipped ½ of 1 per cent more cement and had in stock at the end of the year 7.8 per cent less cement. For those who want exact quantities it may be noted that there were made in 1915 85,914,907 bbl. of Portland cement, 750,863 bbl. of natural cement and 42,678 bbl. of puzzolan cement.

BLAME FOR FAILURE OF CONTRACTORS ON GOVERNMENT LOCK AND DAM WORK.

To the Editors: Noting your comment on the blame for failure of contractors in Government lock and dam work, I wish to mention in addition to your reasons for failure, the incompetence and crooked work of Government inspectors. I recently saw a sample of this on a steel contract for a foundation for machinery. The inspector induced the contractor to employ a friend of his on this work, but owing to this friend being lazy and negligent as well as incompetent, the contractors' foreman was compelled to discharge him. Consequently when the foreman engaged other men to do the work, the inspector condemned 75 per cent of the rivets driven. I was asked to inspect these rivets by the contractor's representative and found the majority of those condemned were tight and well rounded, and steel well pulled up and there was no reason for condemnation. The inspector claimed some slight marks on rivet heads, which amounted to nothing, to be defects and as contractors had no appeal, these rivets had to be cut out. The riveting gang was all expert men who had been steadily employed for 14 years on same class of work and were strictly first-class workmen in every respect.

This contractor's work was held up for 10 days until he could get men to suit the inspector. I may also add that I was told by an outsider that the inspector stated to his friend that no friend of the contractor could drive those rivets to suit him. The workmen had years of experience while the inspector had a civil service examination.

I have been in charge of public work about 35 years and never saw a Government job put through as per even their own specifications at less than 100 per cent more than a first-class contractor would do it for, and I have seen work done by Government engineers that cost $5 for every $1's worth done. If they will make me inspector I will adhere strictly to their specifications and guarantee they cannot even complete their work at 500 per cent higher than the lowest bidder. Faults can always be found in any work if carefully looked over.

Respectfully,
A Construction Superintendent.

CHICAGO VOTES $5,100,000 BOND ISSUE FOR BRIDGE CONSTRUCTION.

The city of Chicago is now in a position to proceed with the removal of all center pier bridges now in the main river, with the exception of the one at Rush St. This latter structure will be replaced by a new bridge under the proposed widening of Michigan Ave. At an election on June 5 the voters of Chicago authorized a bond issue of $5,100,000 for completing its bridge construction program. In addition the sum of $1,488,000 is on hand from a bond issue authorized in 1911. This amount will be applied to the work for 1916. The construction program provides for the erection of bridges at the following locations:

Bridge.	Total estimated cost.	Amount necessary for surveys, preparation of plans and specifications and construction in 1916.
Twelfth Street	$ 650,000.00	$ 650,000.00
One Hundredth Street	300,000.00	300,000.00
Approaches to South California Ave-Bridge	57,000.00	57,000.00
Lawrence Avenue	80,000.00	80,000.00
Kimball Avenue	25,000.00	25,000.00
On or near Carpenter Street	281,000.00	10,000 00
Clark Street	600,000.00	20,000.00
Crawford Avenue, two bridges	100,000.00	6,000.00
Franklin-Orleans	550,000.00	25,000.00
Fuller Street	175,000.00	10,000.00
La Salle Street	550,000.00	40,000.00
Madison Street	450,000.00	50,000 00
One Hundred and Sixth Street	350,000.00	15,000.00
Polk Street	500,000.00	10,000.00
South Kedzie Avenue	50,000.00	50,000.00
Taylor Street	500,000.00	10,000.00
Van Buren Street	500,000.00	30,000.00
Weed Street	220,000.00	15,000.00
Wells Street	650,000.00	60,000.00
Preparing for plans for other bridges	....	25,000.00
	$6,588,000.00	$1,488,000.00

PRACTICAL METHODS OF MEASURING FLOWING WATER.*

The object of this paper is to give a brief resume of the different methods commonly employed in the measurement of flowing water, drawing attention to those purposes for which each method is best adapted, and, finally, discussing in more or less detail some of the most important methods used in flow measurement.

Classification of Methods.—All methods of measurement may be divided into two general classes, viz.: (a) Direct discharge methods; (b) mean velocity-area methods.

The first of these two general classes includes all methods whereby the total discharge is determined directly, independent of any knowledge of the velocity or area of cross section, and embraces the following: (1) Gravimetric, (2) volumetric, (3) weirs, (4) chemical gauging.

In the use of the gravimetric method the total quantity of water flowing for a certain definite length of time is weighed; the total weight divided by the product of the weight of a cubic foot of water, and the length of observation, expressed in seconds, gives the flow in cubic feet per second.

In the volumetric method of measurement the total quantity of water flowing for a certain definite length of time is measured in a previously calibrated tank or measuring basin; this quantity expressed in cubic feet divided by the length of observation in seconds gives the rate of discharge in cubic feet per second.

These two methods obviously are unsuited for field practice, due to a lack of facilities for their use. They are mentioned here because they are the basic measurements to which many other methods are referred. In the hydraulic laboratory they are of prime importance.

Measurement by Weirs.—One of the oldest, usually most trusted, and for certain purposes most useful, methods of stream measurement is by means of weirs. A weir is a vertical obstruction placed in the stream bed containing a notch of either rectangular, trapezoidal, or V form over which the water falls. In cross section of crest there are a large variety of forms, but for measurement of discharge the sharp crested weir is used almost exclusively. Knowing the dimensions of the weir, the only observation necessary for the determination of the discharge is the head or the depth of water passing over the crest.

All this seems very simple. In the case of a small stream no difficulties are likely to be encountered in the actual construction of the weir, in obtaining its exact dimensions or in measuring the head of water over the crest. But when one comes to the selection of a formula to use in computing the discharge his troubles begin. In the different text-books on hydraulics may be found a varied assortment of formulas, all seemingly applicable to the kind of weir used.

In a case of this sort, before the engineer has gone very far, he comes to realize that instead of the problem being simple it is really very difficult, providing, of course, that a high degree of accuracy is desired. It becomes necessary for him to determine the exact conditions under which the experiments were conducted which formed the basis for the development of the formula and the derivation of the coefficients; and, then, after he has done this, he must select that formula which is based on experiments conducted under conditions most nearly resembling his own.

For instance, one may expect to obtain very good results by the use of the Francis formula, making the proper corrections for end contractions and velocity of approach, providing he duplicates the conditions existing during Francis' experiments, as follows:

1. The weir must be sharp-crested and rectangular.
2. The distance from the end of the crest to the side of the channel must be at least three times the head on the weir.
3. The under side of the overfalling sheet of water must be subjected to full atmospheric pressure.
4. The height of the weir must be at least three times the head.
5. The head on the weir must be not less than 5/10 ft. nor much more than 1 5/10 ft.
6. The length of crest must be at least three times the measured head.
7. The velocity of approach must not exceed 1 ft. per second.

However, if any one of the above conditions be violated the results obtained by the use of the formula will not be so trustworthy and it may be advisable to use some other formula, provided one can be found that is based on experiments more similar to those in the case at hand.

Hence, the conclusion may be drawn that the reliability of weir measurements depends very largely upon the intelligence and skill employed in making measurements and computing discharges. If the conditions surrounding the original experiments are faithfully duplicated then the results may be depended upon to be correct within 1 or 2 per cent. Under other conditions errors as great as 10 or 15 per cent are easily possible.

It should be noted here that the place where skill is required in connection with weir measurements is in the installation of the weir and gauge. After this has been successfully accomplished almost anyone with a little practice can read the hook gauge accurately enough for all purposes.

The principal application of the weir lies in the measurement of small streams or canals where the cost of weir construction is not excessive. It is also frequently useful in measuring the discharge from pumps, wells or pipes, which are allowed to flow into a basin and then out over a weir. The advisability of its use in connection with turbine testing is open to question. In this class of work the highest possible degree of accuracy is desirable and in the opinion of many this is best obtained by the chemical method.

Chemical Gauging.—The most recently developed, and, for certain purposes, most important of the direct discharge methods of measurement is by the chemical process. The principle involved in this method is very simple. Briefly, it consists of adding to the stream at a certain definite rate some chemical, usually salt, on account of its low cost. Then at some point down stream, after a uniform mixture has been effected, samples are drawn off and the degree of dilution is determined. If w pounds of salt be added to a stream whose discharge is Q cubic feet per second and after a thorough mixture it is found that n pounds of water contain one pound of salt, the total discharge Q in cubic feet per second will be equal to $\frac{wn}{62.5}$. The success attained by the use of this method depends primarily on the skill of the observers. Two important points should be considered:

First—The chemical must be added at an absolutely constant rate. This is usually accomplished by delivering a concentrated solution to the stream through a small orifice under a constant head. Due to the high specific gravity of the solution the rate of discharge through the orifice cannot be determined by ordinary formula, but must be found by measuring the quantity discharged in a given period.

Second—A thorough, uniform mixture of the chemical with the stream must be secured before samples are taken. The length of time required to secure this mixture can be determined by taking a number of samples at different points in any cross section and determining the variation between them. If they do not vary by more than 1 per cent in the amount of chemical contained the mixture is usually considered satisfactory. Mr. Parker, an English engineer, and one of the pioneers in the use of this method, has formulated the following empirical rules. If V represent the mean velocity of the stream and b the breadth, then, when the average depth lies between 1/10 b and 3/10 b, complete mixture occurs at a distance down stream equal to about six times the width of stream and at a time when the addition of the chemical has continued for at least $\frac{24b}{V}$ seconds. Also sample must not be taken more than $\frac{6b}{V}$ seconds after the addition of the chemical has ceased.

---

*Paper read before the Michigan Engineering Society by C. O Wisler.

Applying these rules to a stream whose width is, say, 50 ft., average depth 6 ft. and mean velocity 3 ft. per second, the samples should be drawn off at a distance of 300 ft. down stream and not until the addition of the chemical has continued at least 400 seconds, or nearly 7 minutes. Furthermore, it would be safe, according to this rule, to draw off samples for 100 seconds, or $1\frac{2}{3}$ minutes, after the addition of the chemical had ceased.

However, attention should be called to the fact that these rules are applicable only to streams whose average depth is at least one-tenth of the width, and streams of this sort are not very common in this country. Consequently, it would seem that in applying this method of measurement to a wide, shallow stream, like the Grand River or the Huron, the best way of determining the proper point for sampling is by trial. That is, go down stream a distance of, say, six times the width, and by taking a number of samples throughout the cross section, determine if the degree of dilution varies by more than 1 per cent in the different samples. If it does, then go farther down stream until a point is found where it does not.

However, the most useful application of the chemical method is not in gauging wide, shallow streams. Such streams can perhaps better be measured by the aid of current meters. But for turbine testing or for gauging rocky, turbulent mountain streams, where a thorough mixture is readily obtained, it is extremely doubtful if any other known method of measurement can compare with this in giving accurate, trustworthy results. In a series of turbine tests at Massena Springs, New York, conducted under the direction of Mr. Benjamin F. Groat, Consulting Engineer for the Aluminum Company of America, five successive tests under exactly the same conditions checked each other within 1/10 of 1 per cent. Of course, it is possible that a constant error affected all the results alike; but, considering the great amount of care exercised in carrying on the experiments, this hardly seems likely, especially when a number of other experimenters have conducted tests of a similar nature which checked within ½ of 1 per cent.

Mean Velocity-Area Methods.—This brings us to a consideration of the second class of flow measurements, viz.: those accomplished by determining the mean velocity and cross sectional area of the stream. Knowing these two qualities, their product gives the discharge. This class of measurements naturally subdivides itself into two groups. The first group comprises those methods whereby the mean velocity of the whole stream is determined directly by one operation, as is done in measurements made by Venturi meters, moving screens, slope determinations, orifices, nozzles and the like, and by the color method. The second group includes those methods whereby the total cross section is subdivided into sections whose area, mean velocity and discharge are determined separately and these discharges summed up to give the total discharge of the stream. The methods falling under this second group differ only in the manner of determining the mean velocity of the sections and comprise the use of surface floats, rod floats, current meters and Pitot tubes.

Consideration of Methods of the First Class.—The methods of measurement falling under the first subdivision have a very wide range of application and a corresponding range of reliability.

Orifices, nozzles, short tubes and the like are generally used only in the measurement of small quantities of water. A sharp edged orifice with an area of 1 sq. ft. or less furnishes a very reliable means for measuring the discharge from a tank or reservoir providing only that the head be relatively high and the velocity of approach low. However, a thorough knowledge should always be had of the conditions surrounding the original experiments upon which are based the determination of the coefficients used. For orifices with an area of more than 1 sq. ft. the coefficients have not been reliably determined.

Velocity determination by the use of a traveling screen is comparatively new. The screen is usually made by stretching canvas on a light frame. This is suspended from a wheeled carriage, which runs on a track, either over or at the side of the channel. By observing the time required for the screen to move a certain distance the mean velocity is at once determined. It is apparent that this method is restricted to open channels of very regular cross section. The cost of equipment is high and the method is seldom used, although under ideal conditions it provides a means of obtaining very good results.

Measurement by slope determination and the use of the Chezy or experimental formula can be relied upon to give only roughly approximate results. Sometimes, however, this is the only method that can be employed, as, for instance, in estimating a flood that has already passed by. If high water marks can be found, as is usually the case, the slope of the stream when the flood was at its peak can be determined by the aid of a level. The mean hydraulic radius, which is the area divided by the wetted perimeter, can also be found by measurement. Then, by a proper exercise of judgment, coupled with a semi-divine knowledge of the correct value of n to use in Kutter's formula, the mean velocity can readily be determined from the formula

$$V = C\sqrt{RS}$$

Unquestionably the Venturi meter provides the most reliable means at the municipal or sanitary engineer's command for the measurement of the velocity of water in pipes flowing under pressure. This instrument consists of a special casting which is inserted in the pipe line. In appearance it resembles two nozzles with their small ends joining, the larger end having the same diameter as the pipe line. The principle involved in the use of the instrument is based on Bernoulli's theorem, a discussion of which, along with formulae for the use of the meter, can be found in any text-book on hydraulics. By obtaining the difference in pressures at the throat and at the inlet with the aid of piezometer tubes the velocity can be determined. With a properly calibrated instrument the results should be very accurate, possibly with an error of less than 1 per cent. By the use of a recording gage in connection with a Venturi meter continuous reliable records of discharge can be obtained with very little effort. Practically the only objection to its use is its cost, as it is rather expensive. However, the first cost is practically the whole cost, and as the instrument is usually used only as a permanent installation where either continuous or intermittent records extending over a period of time are desired, this item should not, in the end, prove objectionable.

Another kind of velocity determination of special interest is the color method as applied to flow in pipes, closed conduits, and open channels of uniform cross section whose depth is at least one-third the width. The process consists briefly in discharging a small quantity of coloring matter into the conduit and noting the length of time required for it to appear at some point further down in the line. In determining the flow in sewers by this method, the coloring can be added at a manhole, preferably near the discharge end, and the elapsed time observed until it appears at the outlet. The distance traveled, divided by the time, gives at once the mean velocity of flow, provided only that the flow is turbulent. As to whether this condition exists or not can be determined in two ways. First, by the use of empirical formulae, such as that developed by Osborne Reynolds, in which

$$V = \frac{.2458}{D\,(1 + .0337\,T + .000221\,T^2)}$$

where D is the diameter of pipe in inches and T is the temperature of the water in degrees Centigrade. If the velocity is as great or greater than that determined by the formula, the flow is turbulent. Another and perhaps better way for determining the condition of flow as regards turbulence is by actual observation.

If, for instance, the flow is turbulent, then water which is at one instant in the center of the pipe, traveling at the maximum velocity, will, an instant later, be whirled out near the side of the pipe and traveling at a lower velocity, and that water which was near the side of the pipe will now be near the center, so that the average velocity of the different particles will be nearly constant, and it will make practically no difference where they may happen to be when the coloring is added—they will in any event reach a point down stream at very nearly the same time. In other words, if the flow is turbulent, the length of the color streak as it appears at the outlet will be surprisingly short, usually not more than 1 per cent of the distance traveled. If the velocity should be decreased, then as the flow approaches stream line motion the color streak at the outlet will lengthen greatly and the method will not be applicable.

In sixty-eight experiments conducted by Parker on a 12-in. pipe, 2,074 ft. long, the greatest length of color streak observed was 14 ft. The coloring first appeared after 598.2 seconds, nearly 10 minutes, and completely disappeared 4 seconds later. Hence, the mean velocity was less than 3.467 ft. per second, and greater than 3.444 ft. per second, the mean value 3.456 ft. per second being perhaps more nearly correct than could have been obtained by any other means. This method has the advantage of being easily applied, is inexpensive, and is capable of giving very good results.

In measuring sewage or water not used for household purposes, a fluorescent dye serves well for coloring. By placing a white surface below the water at the outlet, the eye is aided materially in making the observation. In case the water is to be used for household purposes bran may be used, this being later strained off by the aid of cheesecloth; or permanganate of potash may be used, this being decolorized by the addition of a little ferrous sulphate.

Consideration of Methods of the Second Class.—Measurements falling under the second class of mean velocity-area methods, comprise the most usual methods employed in ordinary measurement of river discharge. The instruments used, as previously stated, are: surface floats, rod floats, current meters and Pitot tubes. A gaging by this method is preferably made from a bridge, but if no bridge is available, and the stream is too deep for wading, then either a boat must be used or a cable suspended across the stream.

The first step after the site for the gaging has been selected is to divide the total width of stream into a number of sections, ranging in length usually from 5 to 10 ft., the limits of these sections being marked either on the bridge or on a wire or rope stretched across the river. The depth at each of these limiting points is determined by a rod or sounding weight, or, better still, the elevations of the bed of stream may be determined by aid of a level and level rod. The next step is to determine the mean velocity for each of these sections.

When this is accomplished by the aid of surface floats, a partially filled bottle with only the neck projecting above the surface may be used to advantage. The surface velocity is determined by noting the time required for the bottle to travel a certain distance, usually 100 ft. Eighty-five to ninety per cent of this surface velocity, depending largely upon the depth of steam and wind conditions, gives approximately the mean velocity for the total depth at that point. After thus determining the mean velocity at the ends of the section, the average of the two is computed, which, multiplied by the area, gives the discharge for that section. The sum of these discharges for all the sections gives the total discharge of the stream. This method gives only approximate results, but is sometimes useful in the determination of flood discharge or in reconnaissance work.

Rod floats can, under proper conditions, be depended upon to give better results, and may, sometimes, be used to advantage in streams where the cross section is uniform for a distance of, say, 100 ft. These floats are designed to give directly the mean velocity in the vertical. Hence, they should have such a length and weight that will just prevent their touching the bottom of the stream and allow a very slight projection above the water surface to prevent any appreciable influence by the wind. There will necessarily be a layer of water between the lower end of the rod and the stream bed. As this layer is moving with a velocity less than the mean in the vertical, the rod, uninfluenced by it, will have a velocity greater than the mean, so that unless coefficients are applied in the computations rod floats give too high velocities. Rods of different lengths must, of course, be used for the different depths. A very satisfactory rod can be made of a piece of 2-in. round wood, to the bottom end of which is fitted a tin tube about 10 in. long, with the lower end closed. The tube should be filled with enough shot or sand to sink it to the proper depth. The rod should be oiled and painted to prevent its becoming water-soaked and sinking to a greater depth than desired.

In canals of unvarying section rod floats should, perhaps, give results as accurate as can be obtained by the use of current meters. However, in the case of natural channels of irregular and rapidly changing sections, the error becomes much greater, and they should not be used.

Current Meters.—Perhaps the most commonly used and most generally applicable method of measuring the velocity of water in open channels at the present time is by the aid of current meters. Of these there are two common types, namely, screw and cup, typical examples of which are the Haskell and the Price meters, respectively.

Velocity is not indicated directly by a current meter but is obtained by the known relation between speed of the wheel and velocity of the water. As this relation is not the same for different meters, it becomes necessary to rate every meter made. Furthermore, the same rating will not hold for any meter throughout its life, so that the rating should be checked from time to time and a new rating table made up whenever the necessity for one becomes apparent.

The current meter and likewise the Pitot Tube determine the velocity only at a point whereas it is desired to known the mean velocity for the entire depth. However, if one takes a number of observations at different depths and plots the results in the form of a curve, plotting velocity against depth, the following facts can be learned:

First, the curve resembles a parabola whose axis is horizontal and at a distance below the surface of about three-tenths of the depth.

Second, the mean velocity occurs at about six-tenths of the depth of the stream.

Third, the mean between the velocities found at two-tenths and eight-tenths also gives the mean for the total depth.

These last two facts afford a ready means for determining the average velocity at any station by taking only one or two observations. Both methods are in common use, the .2 and .8 method giving perhaps slightly the better results. In making an observation by either method the number of revolutions is observed for a period usually of about fifty seconds. From the rating table the corresponding velocity is found. Thenceforth the manner of computing the discharge is the same as described for the float method.

One of the most serious errors affecting current meter measurements occurs when the meter is suspended at the end of a cable as is often done. Unless some restraining device is used when the velocity is more than three feet per second, the meter is carried down stream a distance and raised somewhat in the vertical, and the observer has no means of knowing at just what depth he is making his observation. When the gaging is being made from the downstream side of a bridge, the meter can be held in proper position effectively by attaching to it a rope manipulated from the opposite side of the bridge. If, however, there is no bridge, it may be necessary to put the meter on a rod providing the current is swift.

There are many other possible sources of error affecting current meter measurements, some due to faulty design of meter, others due to carelessness on the part of the observer, but time does not permit of a full discussion of all these. It can safely be said that while current meters afford a ready and useful means of stream gaging, the degree of accuracy attained in the results is not as great as is usually thought. It requires a very careful measurement to give a result within five per cent of the true discharge, and an error of ten per cent or even twenty per cent may easily occur.

Pressure Methods.

One of the simplest methods theoretically for determining the velocity of flowing water, is by converting the velocity head into a pressure head and then measuring this pressure. The conversion is readily effected by the simple expedient of presenting some obstruction to the flow. Accurate measurement of the resulting pressure, however, is not so easy. This measurement is usually made by balancing the pressure either by water column, as is done in the Pitot Tube, or by some mechanical device.

Practically the only pressure instrument used at the present time is the Pitot Tube. This instrument is rated and its manner of use is practically identical with that of the current meter. As to the practical value of the Pitot Tube there is a most remarkable difference of opinion among leading hydraulicians. For instance, quoting from Prof. Lewis F. Moody, of Rensselaer Polytechnic Institute, "The Pitot Tube is perhaps capable of more general application than any other method of measuring the velocity of flowing water, and furnishes one of the most useful tools which the engineer can command." On the other hand, Mr. Clemens Herschel, after quite a lengthy discussion, says, "Pitot Tube, or Pitometer gagings are, therefore, approximations only." The writer is of the opinion, however, that for measuring high velocities and for determining the variations of the velocity throughout the cross-section of a pipe, the Pitot Tube has an unquestioned usefulness.

Briefly summarizing, the writer would suggest the following methods of measurement as being the most practical for the purposes stated:

For gaging wide, shallow streams, use current meters.

For gaging deep, narrow streams, use current meters or salt solution method.

For gaging swift, turbulent mountain streams use salt solution method.

For gaging small streams use current meters or sharp crested weirs.

For gaging open channels of uniform section use current meters or rod floats.

For gaging open channels, narrow, deep and of uniform section use color method, current meters or rod floats.

For turbine testing use salt solution method or sharp crested weirs.

For measuring the flow in sewers, or other closed conduits not flowing under pressure use salt solution or color method.

For measuring flow in pipes under pressure use Venturi Meter, Pitot Tube, salt solution or color method.

For measuring small discharges from tanks or reservoirs use sharp crested orifices.

However, the application of these various methods is more or less elastic, the above being intended only as a general guide.

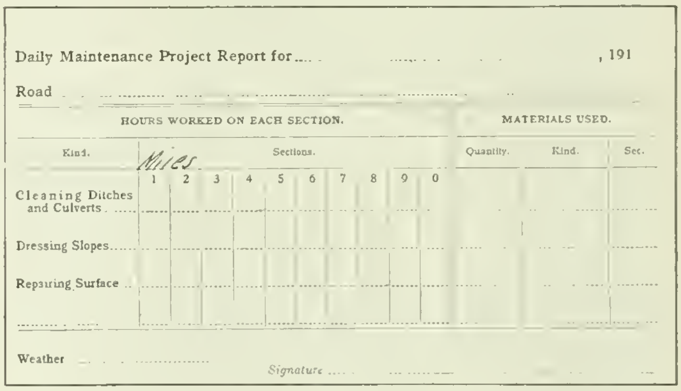
References.

The following are a few of the best references for descriptions of methods of measurement of flowing water:

Chemical Gaging:
Chemi-Hydrometry and Its Application to the Precise Testing of Hydro-Electric Generators. By Benj. F. Groat, M. Am. Soc. C. E. Proceedings of A. S. C. E. for November, 1915.
The Control of Water. By Philip A. Morley Parker. Pages 73-78.
Color Method:
The Control of Water. By Philip A. Morley Parker. Pages 434-436.
Weirs:
Water Supply Paper No. 200. By Robert E. Horton, M. Am. Soc. C. E.
Hydraulics. By Hughes & Safford. Pages 187-236.
Orifices:
Hydraulics. By Hughes & Safford. Pages 123-163.
Venturi Meters
The Control of Water. By Philip A. Morley Parker. Pages 79-84.
Pitot Tubes:
The Control of Water. By Philip A. Morley Parker. Pages 65-72.
Hydraulics. By Hughes & Sanford. Pages 100-114.
Measurement of the Velocity of Flowing Water. By Lewis F. Moody. Proceedings of Engineers' Society of Western Pennsylvania, for May, 1914.
Pitot Tube Formulas, Facts and Fallacies. By Benj. F. Groat. Proceedings of Engineers' Society of Western Pennsylvania for May, 1914.
Current Meters:
River Discharge. By Hoyt & Grover.
Floats:
The Control of Water. By Parker. Pages 57-62.
River Discharge. By Hoyt & Grover.

FORMS AND INSTRUCTIONS FOR ROAD MAINTENANCE.

Organized maintenance is being conducted by the U. S. Office of Public Roads along about 725 miles of through highway from Washington, D. C., to Atlanta, Ga. The plan is a co-operative one between the Office, the State Highway Commissioners and the Commissioners of the counties traversed by the road. The government furnishes the engineers, the state the transportation and the county commissioners the labor, which is worked under the direction of the engineers.



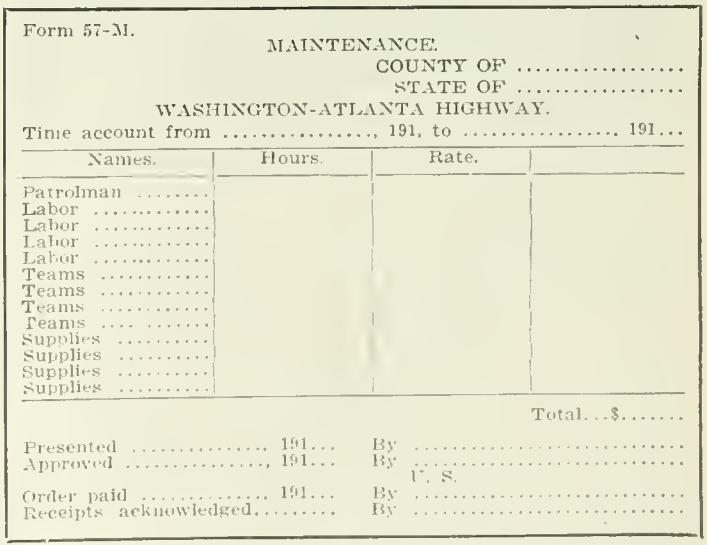
Daily Maintenance Project Report for ...., 191
Road ....

HOURS WORKED ON EACH SECTION.											MATERIALS USED.		
Kind.	Miles				Sections.						Quantity.	Kind.	Sec.
	1	2	3	4	5	6	7	8	9	0			
Cleaning Ditches and Culverts													
Dressing Slopes													
Repairing Surface													

Weather ....
Signature ....

Fig. 1.

Some of the blanks and forms used in the maintenance work are shown in the accompanying illustrations. Fig. 1 is the Daily Maintenance Project Report which is filled in and mailed to the Office of Public Roads. Fig. 2 is the Time Account Blank for Patrolmen. Fig. 3 is the Semi-Monthly Maintenance Progress Report. The patrolmen are worked under the general direction of the Government engineer in charge of the section in each state. The following list of general instructions prepared by Mr.



Form 57-M.
MAINTENANCE.
COUNTY OF ....
STATE OF ....
WASHINGTON-ATLANTA HIGHWAY.
Time account from ...., 191, to .... 191...

Names.	Hours.	Rate.	
Patrolman			
Labor			
Labor			
Labor			
Labor			
Teams			
Teams			
Teams			
Teams			
Supplies			
Supplies			
Supplies			
Supplies			

Total...$.......

Presented .... 191... By ....
Approved ...., 191... By ....
U. S.
Order paid .... 191... By ....
Receipts acknowledged......... By ....

Fig. 2.

D. H. Winslow, U. S. Superintendent of Construction, Durham, N. C., indicates the duties of the patrol force:

Inspect your road, its entire section, during a rainy day and locate all pond holes.

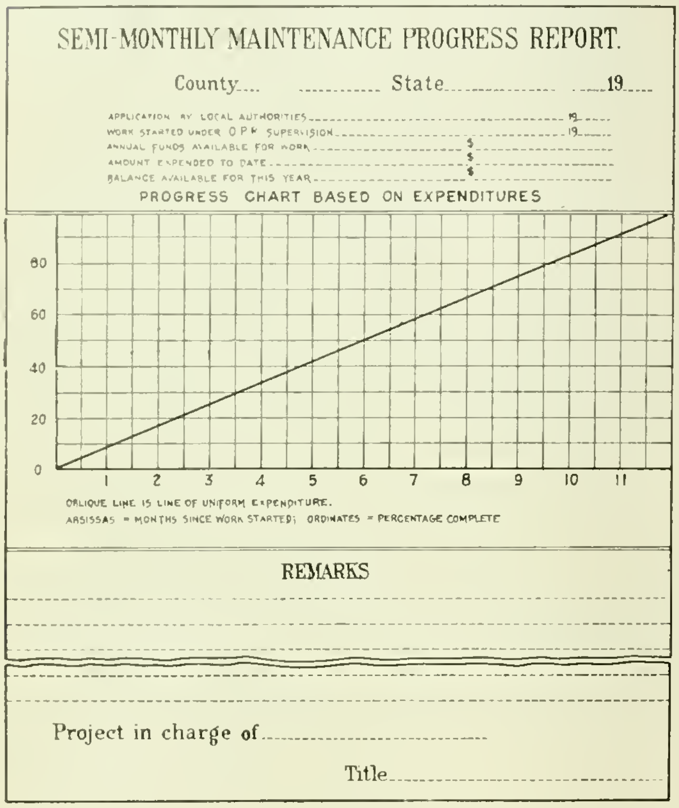
Use the road drag immediately after a rain.

Fill all depressions with good material.

On no account use worn-out material, sod or sand from ditches.

Remove all glass, tin cans, nails, old iron, etc., from the roadbed.

Renew all defective plank at culverts when necessary.



SEMI-MONTHLY MAINTENANCE PROGRESS REPORT.

County.... .... State.................. ....19....

APPLICATION BY LOCAL AUTHORITIES.................................19....
WORK STARTED UNDER O P R SUPERVISION.............................19....
ANNUAL FUNDS AVAILABLE FOR WORK.................$...................
AMOUNT EXPENDED TO DATE.........................$...................
BALANCE AVAILABLE FOR THIS YEAR.................$...................

PROGRESS CHART BASED ON EXPENDITURES

80
60
40
20
0
1
2
3
4
5
6
7
8
9
10
11

OBLIQUE LINE IS LINE OF UNIFORM EXPENDITURE.
ABSISSAS = MONTHS SINCE WORK STARTED; ORDINATES = PERCENTAGE COMPLETE

REMARKS

Project in charge of..............................

Title..............................

Fig. 3.

Should your road surface be very rough, a spike toothed harrow used while the road is wet will improve an earth, sand-clay, top-soil or gravel surface.

Cut the weeds both sides of the road. Use a mowing machine for this purpose if practical.

Cut all brush at inside of the curves and at railway crossings and culverts.

Remove the ridge between the wheel rut and the gutter by using the one-horse cultivator and then use the drag to push the material toward the ditch.

See that all culverts are clear, with outlets and inlets in good order.

Paint all guard rails at culverts and bridges, etc.

Renew all signboards, mile-posts, etc., when necessary and give the traveling public all the advice in regard to the routes within your power.

See that all labor and teams in your employ render full and satisfactory service.

Receive all information and criticism from the general public in a courteous manner.

COST OF LAYING WATER MAINS IN CITY STREETS.

From the annual report for 1914-15 of the Bureau of Water, Buffalo, N. Y., we take the following tabulation of costs of laying water mains in dirt, stone paved and asphalt paved streets:

4-inch in dirt street, cost per foot	$ .95
6-inch in dirt street, cost per foot	1.10
6-inch in asphalt street, cost per foot	1.85
6-inch in stone street, cost per foot	1.30
6-inch in rock (sewer trench), cost per foot	1.40
8-inch in dirt street, cost per foot	1.25
8-inch in stone street, cost per foot	1.35
8-inch in asphalt street, cost per foot	1.75
10-inch in dirt street, cost per foot	1.50
10-inch in stone street, cost per foot	1.60
10-inch in asphalt street, cost per foot	2.00
12-inch in dirt street, cost per foot	2.50
12-inch in stone street, cost per foot	2.70
12-inch in asphalt street, cost per foot	3.00
16-inch in dirt street, cost per foot	3.00
16-inch in stone street, cost per foot	4.00
16-inch in asphalt street, cost per foot	5.00
24-inch, cost per foot	10.00
36-inch, cost per foot	15.00
48-inch, cost per foot	20.00
48-inch, laid on hill, cost per foot	25.00

HIGHWAY CONSTRUCTION IN ALABAMA IN 1915.

The state of Alabama has 55,740 miles of roads within its limits, according to statistics compiled by Mr. R. P. Boyd, Assistant State Highway Engineer. Of the mileage 47,140 are classified as unimproved. The mileage of improved highway on Jan. 1, 1916, was as follows:

	Miles.
Macadam	502
Chert	1,241
Gravel	1,673
Sand-clay	2,439
Graded	2,758

In addition there were 106,181 lin. ft. of steel bridges and 17,093 lin. ft. of concrete bridges in the various counties of the state.

The expenditures during the year April 1, 1915-April 1, 1916, for state aid highway construction amounted to $289,808. The aggregate mileage of roads improved was as follows: Macadam, 16.92 miles; chert, 19.17 miles; gravel, 41.50 miles; sand-clay, 62.59 miles; graded, 37.32 miles. In addition 1,064 lin. ft. of steel or concrete bridges were constructed. The mileage and cost of the various types of roads by counties were as follows:

County.	Miles.	Cost per mile.
MACADAM.		
Cullman	13.00[1]	.....
Lawrence	1.38	$3,447
Madison	1.54	7,122
Morgan	1.00	.....
[1]Slag.		
CHERT.		
Bibb	3.31	3,250
Blount	2.75	1,679
Calhoun	2.00	2,493
Cullman	1.02	6,396
De Kalb	2.52	2,406
Etowah	2.85	1,966
Jefferson	2.72	4,253
St. Clair	2.00	1,672
GRAVEL.		
Dallas	2.75	1,420
Elmore	3.50	512
Fayette	4.54	1,053
Franklin	.12	4,976
Hale	1.06	4,740
Macon	7.10	.....
Mobile	1.90	2,978
Perry	4.80	.....
Talladega	9.86	1,768
Tuscaloosa	3.86	2,245
Wilcox	2.01	2,820
SAND-CLAY.		
Bullock	10.13	903
Butler	1.57	1,999
Chambers	3.91	1,945
Clarke	10.16	941
Conecuh	7.37	1,591
Coosa	2.98	1,540
Covington	6.44	1,083
Crenshaw	2.00	2,308
Geneva	3.30	1,419
Henry	7.25	662
Houston	3.03	943
Pickens	4.45	1,428
GRADED.		
Jackson	6	1,818
Limestone	2.06	1,819
Lowndes	4.64	1,046
Marion	3.45	1,409
Morgan	1.25	.....
Randolph	5.23	1,417
Shelby	1.47	2,452
St. Clair	2.00	.....
Tallapoosa	7.30	1,100
Walker	2.61	1,604
Wilcox	1.31	.....

A considerable amount of highway construction also was carried out by the counties with money obtained from bond and warrant issues and from the general fund. The total amount from the general fund spent on roads during the year Jan. 1, 1915 to Jan. 1, 1916, was $1,935,747. The amount expended from the general fund on bridges was $504,978. The amount expended on roads and bridges from bonds or warrant issues was $1,606,654. The mileage and types of road constructed by the counties were as follows:

	Miles.
Macadam	17
Chert	117.9
Gravel	342.5
Sand-clay	515.59
Graded and drained	818.7
Steel bridges, lin. ft.	7,360
Concrete bridges, lin. ft.	3,023

W. S. Keller, Montgomery, Ala., is State Highway Engineer of Alabama. R. P. Boyd is Assistant State Highway Engineer.

DRIVING A WELL TO THE TRINITY SANDS AT DALLAS, TEXAS.

The well is 2,850 ft. deep and was driven for the Southern Methodist University at Dallas. Its feature of principal interest is the method of sealing by cementation the well against entrance of all waters except those from the Trinity sands. The driving methods as described by Ernest L. Myers, Myers & Noyes, Engineers, Dallas, Tex., in a paper for the Southwestern Water Works Association, were as follows:

A contract and specifications were prepared for a well to the Trinity Sands and bids called for. Bids were secured ranging from $20,000 to $23,500 for the well complete. The bid of J. E. Faucett & Co., of Dallas, for $20,000 was accepted, and the contract signed June 2, 1915. Drilling was begun July 1, and completed Oct. 17. Two days were lost due to a severe storm and ten days were lost allowing the cement to set after cementing the 6-in. casing. The total depth of the well is 2,850 ft. The time of actual drilling was 67 days, which, I believe, is a record in this locality for a well of like depth. There was no loss of time due to loss of tools or like mishaps. A small amount of time was lost repairing the engines and pumps and sharpening the bits.

Plant.—The contractor provided himself with the most up-to-date equipment, including a special section of square drill stem with a grooved roller device for gripping it in the rotary. Also corrugated, tapered wedges for gripping and holding the drill line when coming out or going in the hole. The standard heavy rotary type well rig was used in drilling the well. The derrick was 113 ft. in height and constructed in a very substantial manner. The 6-in. drill stem was of heavy steel casing, equipped with tapered tool steel joints and extra long heavy couplings. The 4-in. drill stem was of extra heavy Reading drill pipe, equipped with tapered tool steel joints. Only the square drill stem and one section of special drill pipe was used through the rotary. This prevented any damage to the balance of the casing in drilling.

The heavy tongs and elevators were swung in the derrick by means of hooks and cables, making them easy to handle and decreasing the amount of heavy lifting necessary.

Oil fuel was used under the boiler and was piped from a railway switch in the rear of the main university buildings, one-half mile from the site of the well. The water for drilling and boiler use was obtained principally by constructing a low earth and sack dam in Turtle Creek. Considerable trouble was experienced from leakage under the dam, due to the smooth rock bed of the creek. The leakage was partially stopped by pumping drill mud into the pond above the dam.

Materials Penetrated.—The hole was started 14 in. in diameter. After passing through 6 ft. of surface soil, a soft lime rock, locally called "White Rock," was encountered. At 13½ ft. a 12-in. surface casing was set. The size of the hole was then reduced to 10½ in. in diameter. After passing through 159 ft. of White Rock, shale interlayed with shallow layers of lime rock was encountered to a depth of 408 ft. From this point down to a depth of 672 ft. the formation was largely of gumbo. At this depth the first of the Woodbine sands was struck. Water sands interlayed with streaks of gumbo, shale and some lime rock were encountered down to 998 ft. The heaviest as well as the deepest strata of Woodbine water bearing sand was 51 ft. in thickness.

The Weatherford limestone was encountered at 1,063 ft. With the exception of thin layers of gumbo and shale this formation continued to the upper Paluxy Water sands at 1,617 ft. At a depth of 1,789 ft. the 8-in. casing was set in hard lime rock. The hole was then reduced to 7⅞ in. in diameter. The Paluxy sands interspersed with thin layers of limestone and gumbo continued to 1,764 ft. This material caused very hard, slow drilling.

The thickest layer of Paluxy water sand encountered was 42 ft. in depth, lying between 1,638 and 1,730 ft. After passing out of the Paluxy water sands, alternating layers of gumbo and lime rock, with some sand and boulders were encountered to 1,945 ft. From 1,945 ft. to 2,291 ft. the formation was principally of very hard lime rock. At 2,291 ft. the upper layer of the Glen Rose water sand was struck. The Glen Rose water sands interlayed with numerous layers of red gumbo and very hard sand rock extended to 2,448 ft. The upper and thickest layer was 44 ft. in depth.

From 2,448 to 2,523 ft. the formation consisted of relatively thin layers of hard lime and sand rocks. From 2,523 to 2,603 ft. thin layers of red shale, gumbo and sand rock were encountered. At 2,603 ft. the cap rock of the Trinity sands was struck. This was a very hard sandstone formation. At 2,630 ft. the 6-in. casing was set and cemented in place. The size of the hole was then reduced to 5⅞ in. in diameter.

After drilling 2½ ft. the softer, water-bearing Trinity sand was struck. At 2,770 ft. a layer of hard sand and lime rock 8 ft. thick was struck. Passing through this formation Trinity sands were again encountered. At 2,807 ft. drilling passed out of the Trinity sands. Drilling was continued to 2,850 ft., passing through lime and sand rock and shale. At this point it was considered unnecessary to drill further, as it was believed that the last of the Trinity sands were passed through.

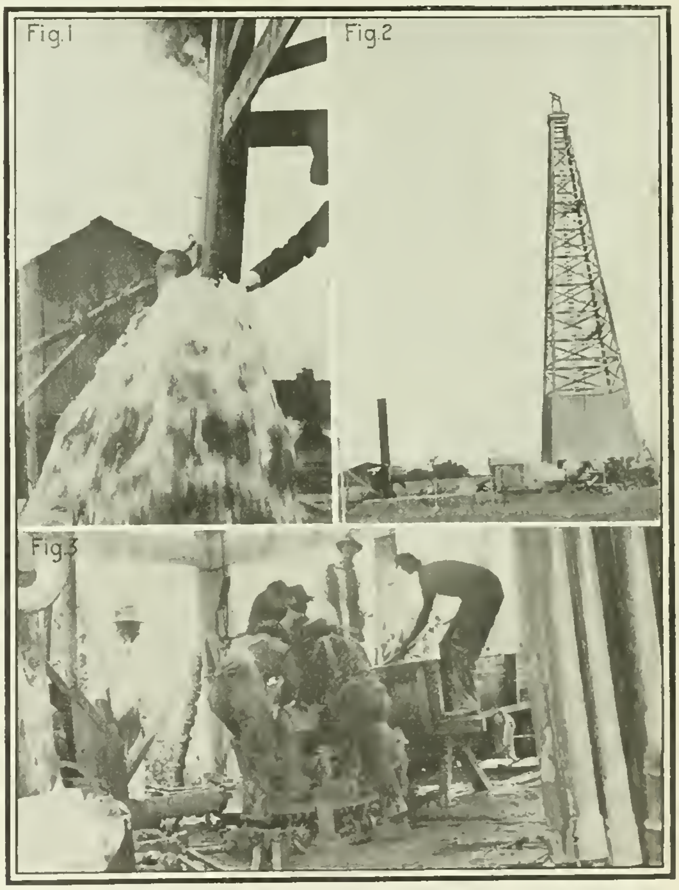


Fig. 1—Well Flowing After Cementation. Fig. 2—Well Drilling Derrick 113 ft. High. Fig. 3—Cementing 6-in. Well Casing.

After reaming the hole, 243 ft. of 4½-in. perforated liner was set. The liner had 75 ½-in. holes per foot in depth. The well was then equipped with agate valve and delivery pipe and allowed to flow freely for several days, to clear itself of drill mud and loose sand. The well began flowing soon after passing through the cap rock, but did not flow in any considerable amount until the drilling had penetrated well into the strata. At the time of completing the well, the water rose in drill pipe to a height of 65 to 75 ft. above the ground level. Weir measurements indicated a flow of a half million gallons per 24 hours.

Cementing Casing.—The principal feature in which this well differs from the other deep water wells constructed in this locality, is the method of casing off the waters other than that of the Trinity Sands Strata. This was done by surrounding the 6-in. casing for several hundred feet with cement grout. This cement grout extending from the Trinity Sands upward to, or near, the lower end of the 8-in. casing.

Although the cementing process is a very common one in the oil fields of Louisiana and also in California, little information is available in regard to the method. Two papers are available on this subject: One by Paul M. Paine, in Transactions, American Society of Civil Engineers, December, 1913, on methods used in cementing deep wells in California; and the other (the author of which I have not the name), describing the methods used in cementing the oil wells of Louisiana to prevent the entrance of salt water into the wells.

The first describes the method commonly used in California, which is to introduce a small pipe, extending to the bottom of the well, inside the casing to be set. A tight joint is then made between the top of the casing and the small pipe. The casing is then lifted clear of the bottom and cement grout pumped down through the small pipe to the bottom of the well. The casing being filled with drill mud, confined by the tight joint at the top, the grout is forced up around the outside of the casing filling the space between the casing and the walls of the, hole.

The method described in the second paper is called the plug method. It is used with success in the Louisiana field. This method is much simpler and is inexpensive. In this method the casing is first set in the well and bailed down for several hundred feet, depending on the amount of cement to be used. A plug loosely fitting the casing is then dropped in and the cement grout poured in on top of this plug. A second plug is then introduced on top of the cement. Connection with the pump is made to the top of the casing, and the casing lifted clear of the bottom of the hole. The pump is then started. The plugs, with the column of grout between them are forecd downward to the bottom of the well, the drill mud below the bottom plug being forced out and up around the casing. Upon reaching the bottom of the hole the lower plug cuts off the circulation, stalling the pump. The casing is then raised just enough to allow the lower plug to pass out. The lower plug clears the casing of mud as it advances and upon passing out of the bottom of the casing allows the cement grout to be forced upward around the outside of the casing, filling the space between the casing and the walls of the hole. When the top plug reaches the bottom of the well, it is prevented from passing out by the lower plug and the circulation is stopped. The casing is again seated on the bottom of the hole and the well allowed to stand from ten days to two weeks before resuming drilling.

It was decided to use the plug method in cementing the University Well, because of its simplicity and the familiarity of the local drillers with this method. The cap rock of the Trinity Sands was reached on Sept. 26, but as there was some doubt of its being the cap rock of the Trinity Sands, drilling was continued for a depth of 27 ft. into the formation. After penetrating to this depth it was decided that there was little doubt of this being the cap rock of the Trinity Sands and it was decided to set the 6-in. casing. On the night of Oct. 28 the 6-in. casing was started in the hole and by the middle of the next forenoon was seated on the cap rock, an ordinary set shoe being used on the bottom of the 6-in. casing.

Eleven hundred feet of the 4-in. drill stem with the lower end plugged was run into the 6-in. casing to bail the well. This forced the drill mud to flow out over the top of the casing so that when the drill pipe was withdrawn the casing was empty for a depth of from 300 to 400 ft. from the top.

A large mixing box 16 ft. long by 5 ft. in width by 1½ ft. in depth, having a gate in one end, was built on the platform of the derrick. A short trough was run from the gate to the top of the 6-in. casing. A batch of 20 sacks of cement and 40 sacks of sand was mixed in the box and water added to make a very thin paste. Mixing was continued until the paste was run into the well.

A circular wooden plug 2 ft. in length, which had previously been passed through a section of 6-in. casing to make sure that it would not lodge, was dropped in on top of the drill mud remaining in the casing. This plug had a folded cement sack fastened to its top to prevent any cement passing the plug. The 6-in. casing was lifted clear of the bottom of the hole. The cement grout was then run in on top of the plug as quickly as possible. The upper plug, which was similar to the lower plug, except that it had a stick 3 or 4 ft. in length projecting downward from its lower end, was dropped in on top of the grout. The swivel connection was then screwed onto the top of the casing and the pump started. After some minutes the mud began to flow from between the 6 and 8-in. casings showing that circulation had begun.

After a period of 15 minutes had elapsed the pump came to a dead stop, indicating that the lower plug had reached the bottom of the hole, entirely cutting off the circulation. The 6-in. casing was then lifted sufficiently to allow the plug to pass out and circulation was again established.

After the first plug had passed out the pump gradually began to slow down, due to the great pressure necessary to force the heavy cement grout upward through the small cavity surrounding the casing. The pump slowed down to such an extent near the end that it was feared that it would stop before the top plug reached bottom. After about 45 minutes of pumping the pump stalled. The pump was operating at so low a speed at the time that some doubt was felt as to whether the top plug had reached the bottom or whether the load had become too great for the pump.

The 6-in. casing was then lowered upon bottom, but failed to go to its original seat by about 6 or 8-in. This may have been due to the cavings in the hole or to sand settling out of the grout, as the sand which was used showed a tendency to do this in the mixing box.

The well was then allowed to stand undisturbed for a period of five days. The 4-in drill pipe was then run in and the 6-in. casing washed free from mud. The plugs were found to be on bottom. After 10 days' time drilling was again resumed. The plugs and the small amount of grout remaining in the casing was drilled out. After drilling 2½ ft. the cap rock was passed through and the soft water sand struck. The well began to flow soon after and the flow gradually increased until drilling had progressed well toward the bottom of the sand.

CHEMICAL METHOD OF GAGING STREAM FLOW.

The method of measuring flowing water by adding a known quantity of chemical and after diffusion measuring the amount of chemical found in a specified volume of water, was described and discussed in our issue of Sept. 16, 1914. In a paper before the Maine Society of Civil Engineers, Mr. Walter H. Sawyer, Lewiston, Me., discusses his recent experiences with the method as follows: In the writer's opinion, this process of measuring flowing water if properly conducted, is probably more nearly correct than any other method used by engineers today, with the exception of a tank measurement, being even better than a weir measurement.

The process was first used in about 1896 by Charles Edmund Stromeyer for the purpose of measuring the amount of feed water and circulation water in marine engines and condensers. See minutes of the Institute of Civil Engineers, January, 1905. The method has been used successfully at the Holtwood plant of the Pennsylvania Water & Power Co., Holtwood, Pa. (For an account of this test and a very exhaustive treatment of the whole subject, see article by B. F. Groat, Proceedings of the American Society of Civil Engineers, November, 1915.) This method was also used in testing large hydraulic units at Messina, N. Y.

In attempting to use the chemical method with the river waters of Maine it was very early found that the amount of impurities contained in the water as the result of the discharge of manufacturing wastes from the paper mills and other manufacturing concerns, would make the method of little use. For instance, at Lewiston, it was found that on the evaporation of 500 cu. cm. to 10 cu. cm. that a dark colored, muddy liquor was obtained which disguised the color reaction when the chlorine present had been neutralized by nitrate of silver. Attempts were made to clarify the water before evaporation, but the method of clarification introduced errors and it was found that this was impracticable. There is no doubt that with considerable practice with the water from our Maine rivers that they could be measured with some degree of accuracy, but as the character of the water varies from day to day and sometimes even from hour to hour, the method is of little use to the engineers of Maine.

It was to overcome this difficulty and present a practical method of measuring water that the writer was led to investigate the practicability of ascertaining if the amount of salt or other chemicals in water could be accurately determined by measuring the resistance of the water to the passage of an electric current. After many trials and failures, a method has been devised by which the amount of salt or other electrolyte contained in waters may be ascertained even in waters containing large amounts of electrolyte used, as well as other electrolytes as impurities.

It is not my purpose to describe this method at this meeting, as I intend to make tests in a large tank as soon as this can be arranged for. So far as the writer has gone, the method has been checked in the laboratory and it has been found that we can determine the amount of salt added to solutions within a very small fraction of a per cent. Practical tests have also been made against the standard weir with concordant results.

The method has been made the subject to a patent application merely for the purpose of protecting the large amount of work that has been done, with no intention, however, of preventing engineers of making use of the method. The patent office so far has looked with favor on the application.

PRESENT STATUS OF EARLIER STATE AID ROADS IN NEW YORK.

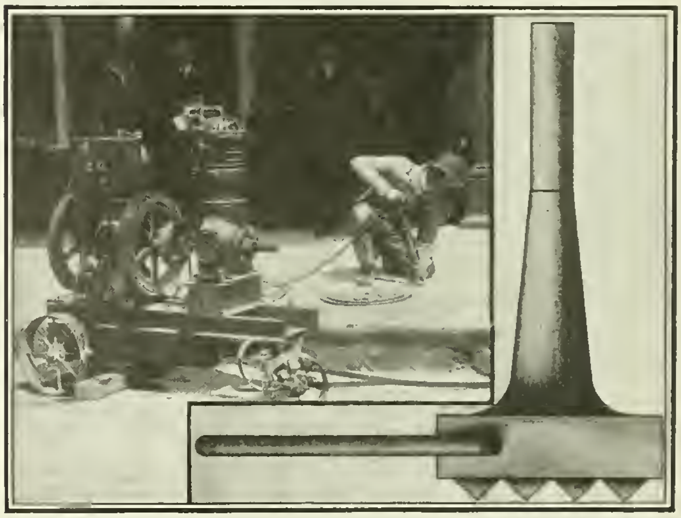
The accompanying tabulation, abstracted from a recently issued bulletin of the New York State Commission of Highways, shows the details of construction and present status of some of the earlier roads constructed under the state aid plan. The 18 highways listed in the table were placed under contract prior to 1902. They were of the waterbound macadam type. It is interesting to note that the average time between the acceptance of these roads and their resurfacing was approximately 11 years. For two of the roads it was over 16 years. The roads are classified as county highways, the state's share of their cost being 50 per cent. In the table the item "total cost" includes state, county and village expenditures to cover construction, engineering and inspection. The "cost per square yard" excludes all items except those making up the pavement and its foundation.

A PORTABLE OUTFIT FOR ROUGHING STONE SIDEWALKS.

(Contributed.)

The first outfit ever constructed for roughing stone sidewalks was recently put on the market by the Gardner Governor Co., Quincy, Ill. The outfit was thoroughly tested by the Brinkoetter Monumental Co. of Quincy and they are using the first machine with great success in Quincy and surrounding cities.

The outfit consists of an air-cooled air compressor driven by a gasoline engine, mounted on a light steel truck. An air receiver is held under the truck. The compressor is a Gardner-Rix vertical, air-cooled, oil-splash lubricated machine connected by a coupling to the engine. The compressor valves are of thin flexible sheet steel, and cannot be drawn into the cylinder.



Portable Outfit for Roughing Stone Sidewalks.

The tool used is an ordinary plug drill fitted with a case hardened steel block with 16 sharpened raised points. The block, as shown in the cut, has a wire handle which helps to guide the tool. In chipping around cracks, posts set into the sidewalk, etc., a trimming tool is used. An

DETAILS OF CONSTRUCTION AND PRESENT STATUS OF 18 COUNTY HIGHWAYS IN NEW YORK STATE CONSTRUCTED FROM 1898 TO 1902.

					Bottom		Top							Present pavement	
Highway No.	County.	Miles accepted.	Pavement width, ft.	Roadway width, ft.	Material.	Thickness, ins.	Material.	Thickness, ins.	Binder.	Cost per sq. yd. pavement.	Cost per mile, 16-ft. surface, 26-ft. roadway.	Date of acceptance.	Year resurfaced.	Miles.	Type.
1	Schenectady	2	16	22	Li.	4	Tr.	2	Sc., water	.....	.....[1]	12-98	1915[2]	.91	Bit. Mac.
2	Erie	6.54	12	22	Lo. St.	4	Tr.	2	Sc., water	.....	.....[3]	5-00	1909[4]	4.61	Brick
3	Oneida	2.25	12	18	Li.	4	Tr.	2	Sc., water	.....	$9,680	12-98	1915	1	Bit. Mac.
4	Columbia	1 23	16	21	Grv.	4	Grv.	2	Sc., water	.....	.....[5]	8-99	1910	1.23	Grv., Bit. Mac.
5	Monroe	2.45	12	22	Li.	4	Tr.	2	Sc., water	.....	.....[6]	11-00	1913[7]	1.45	Bit. Mac.
6	Monroe	6.53	16	26	Med. Sst.	4	Tr.	2	Li. Sc., water	.....	6,130	7-00	1909	3.20[8]	Bit. Mac.
7	Albany	1.04	15	22	Li.	4	Tr.	2	Sc., water	$0.604	15,360	7-02	1914	1.04	Brick
8	Onondaga	1.20	15	22	App.	6[9]	Tr.	3	Sc., water	.....	.....[10]	11-00	1912	1.20	Bit. Mac.
9	Onondaga	.61	15	22	App.	6[9]	Tr.	3	Li. Sc., water	.....	.....[11]	8-00	1912	.61	Bit. Mac.
10	Rensselaer	1.00	15	22	Li.	4	Tr.	2	Sc., water	.40	7,680	4-00	1910	.48	Bit. Mac.
11	Rensselaer	1.03	15	22	Li.	4	Tr.	2	Li. Sc., water	.....	.....[12]	1-01	....	....	Oiled
13	Chemung	2.60	16	20	Lo. St.	4	Tr.	2	Sc., water	.....	8,040	9-00	1910	2.60	W. B. H. O.
14	Herkimer	1 11	15	22	Gn.	4	Tr.	2	Li. Sc., water	.501	7,450	5-01	1914	1.11	Bit. Mac.
15	Monroe	.63	16	22	Lo. Li.	4	Tr.	2	Li. Sc., water	.....	11,500	8 00	1911	.63	W. B. Glu.
16	Ulster	5.66	12	16	Lo. Bl.	3	Lo. Bl.	3	Sc., water	.408	6,260	11-00	1910	5.66	W. B. H. O.
17	Westchester	.60	16	22	App.	4	Tr.	2	Li. Sc., water	.636	10,320	6-03	1909	.60	W. B. C. O.
18	Westchester	3.06	16	22	Lo. St.	4	Tr.	2	Li. Sc., water	.669	8,950	12-01	1909	3.06	W. B. C. O.
19	Westchester	2.79	16	22	Lo. St.	4	Tr.	2	Li. Sc., water	.562	10,040	9-01	1909	2.79	W. B. C. O.

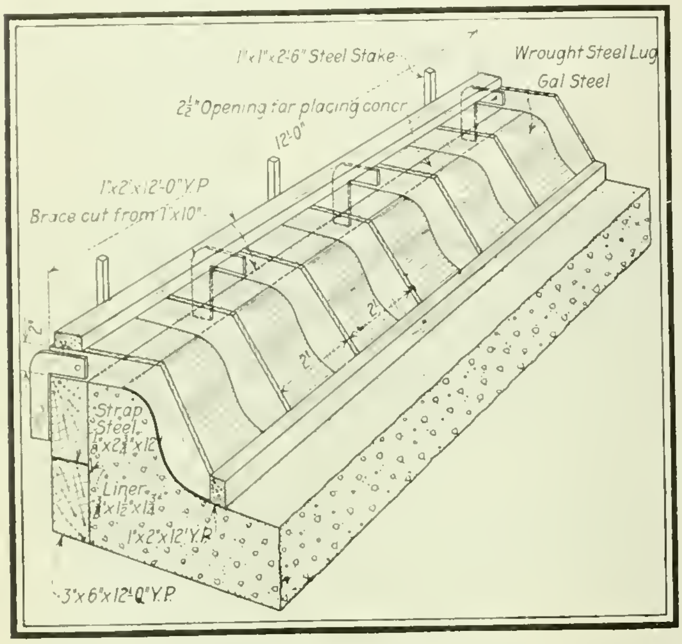
Abbreviations: Li., limestone; Tr., trap; Sc., screenings; Lo. St., local stone, Grv., gravel; Med. Sst., Medina sandstone; App., approved stone; Gn., gneiss; Lo. Bl., local bluestone; Bit. Mac., bituminous macadam, W. B., waterbound; H. O., asphaltic hot oil; Glu., glutrin or lignim; C. O., asphaltic cold oil.

[1] Total cost, $16,518. [2] ½ mile resurfaced with brick in 1913. [3] Total cost, $30,929. [4] 1.9 miles resurfaced in 1912 with brick. [5] Total cost, $9,993. [6] Total cost, $13,899. [7] 1 mile resurfaced in 1910; present pavement amiesite. [8] 3.33 miles resurfaced in 1910; present pavement 1.69 miles Bit. Mac., 1.64 miles concrete cubes. [9] 4-in. approved stone, 2-in. limestone. [10] Total cost, $12,890. [11] Total cost, $7,733. [12] Total cost, $10,643.

unloading device furnished with the compressor, keeps the air at exactly the correct pressure for the most efficient work.

INTEGRAL CURB FORM.

A simple integral curb form was used with excellent results in connection with concrete paving work at East Milwaukee, Wis., last year. The form was designed by Joseph Dean of the Dean Construction Co., Milwaukee, Wis., and proved so successful that the engineer specified its use by all other contractors doing work for the village. The illustration shows some details of the form. As soon as the pavement is struck off the form is set in place and any tendency for it to rise when concrete is placed behind it is overcome by placing at 12-ft. intervals along the forms, worthless cement sacks half filled with sand. Most of the East Milwaukee pavement is of the 2-course type, the base being a 1:2½:4 mix and the top a 1:1½:2½ granite mixture. That portion of the integral curb extending above the pavement is made of the same mixture as the top course of the pavement.



Integral Curb Form.

LOSSES OF WATER BY SEEPAGE FROM IRRIGATION CANALS.

During the years 1912 and 1913, 118 sections of Idaho canals were measured for the determination of the seepage losses. These canals varied in discharge from 0.07 cu. ft. per second to over 3,190 cu. ft. per second, and in cross section from 0.117 sq. ft. to 984 sq. ft. A total of 287.31 linear miles was included, covering all of the common soil types of Idaho, and it is believed sufficient data have been secured to furnish a substantial basis for estimating the losses to which the canals of this state will be subject. A study of these measurements by Don H. Bark, Irrigation Engineer, U. S. Department of Agriculture, Bulletin 339, gives the following conclusions:

(1) Small laterals carrying 1 sec. ft. and less almost invariably lose a large part of the water carried, and the percentage of loss decreases rapidly as the volume carried is increased, thus emphasizing the desirability of rotation systems where the necessity of carrying small amounts is eliminated.

(2) Since certain types of soil have a fairly uniform loss per square foot of canal bed, canals should be designed, other things being equal, with as small a wetted perimeter as possible in comparison to their cross sections.

(3) Porous irrigated land above a canal may cause it to gain instead of lose.

(4) Canals in average southern Idaho soil, which is a medium clay loam, should be designed to withstand a loss of 0.5 to 1.5 cu. ft. per square foot of canal bed in 24 hours; 0.5 cu. ft. per square foot per day is a safe basis for impervious clay loam soil, about 1 cu. ft. per day for medium soil, and 1.5 to 2 cu. ft. per square foot per day is a safe basis for somewhat pervious soils.

(5) One per cent per mile is a safe basis for the loss in medium southern Idaho soil with capacities in excess of 200 sec. ft.

(6) Canals in gravelly soil should be designed to withstand a loss of 2.5 to 5 cu. ft. per square foot of canal bed in 24 hours, depending upon the porosity of the gravel, although it is probable that lining would be profitable if the higher loss were experienced. The procedure must be determined by local economic conditions.

(7) A project having a comparatively long main canal, constructed through earth and unlined, may lose from 20 to as high as 50 per cent of the water diverted before it reaches the farms even in the impervious soils.

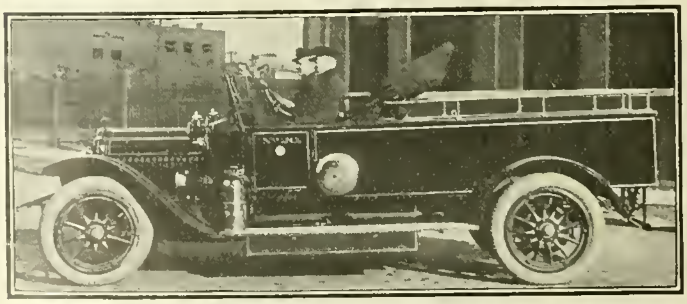
A GAS ACCIDENT EMERGENCY MOTOR TRUCK.

(Contributed.)

Many lives have been saved and heavy property losses averted in the city of Chicago, since the installation of a new emergency truck by the Peoples Gas Light and Coke Company. The scope of service rendered by this truck is not limited to the property holdings of the company or to safeguarding the lives of its employes. It responds to every big fire alarm, gas leaks, sewer and street cave-ins, accidents to buildings, asphyxiation cases, suicides, drownings, leaking gas mains and meters and similar emergencies, rendering first aid to the injured and using the most modern type of pulmotor to revive unconscious victims. The attendants in charge of the truck are experts in the use of the pulmotor and have rendered invaluable service.

The truck covers the entire city of Chicago, an area of over 80 square miles of territory. It can be summoned out at any hour of the day or night without expense to the city, corporation, contractor, physician or private individual. Physicians have highly praised the work of this truck and the speed which it is able to make frequently enables it to reach the injured person before a physician can arrive.

The truck was built by the White Company of Cleveland. It has a capacity of 1½ tons and a 45 H.P. motor. In answering fire calls it is the duty of the attendants to rush into the burning building, turn off the gas or render such other assistance to the injured or entrapped persons as it is possible for them to perform. Before the truck was purchased by the Peoples Company, firemen were greatly handicapped in discovering gas leaks or locating the shut-off valves. Delay of this kind was very dangerous and frequently gas explosions followed small fires that otherwise could have been averted had the fire fighters been able to quickly shut off the gas. The emergency men know the exact location of all gas lines, electric light connections, etc., and are able to render quick assistance.



Gas Accident Emergency Truck, Chicago, Ill.

DESIGN AND CONSTRUCTION OF THE HARLEM RIVER FOUR-TRACK SUBWAY TUNNEL.

Describes and illustrates design features of this four-track subway tunnel in New York City and gives a detailed discription of the construction methods used on each part of the work. The article is an exceptionally complete description of this work, which consisted of constructing the tubes in units, floating them to place, sinking the tubes, and concreting them.

Part II.

Construction Plan.—The general method of constructing the subaqueous section was essentially the same as that used in building the Michigan Central R. R. tunnel under the Detroit River at Detroit, Mich., and in the second time in its history that this method has been used. Only such modifications were made as were dictated by local conditions and other circumstances.

This method comprises first the dredging of a channel in the bottom of the river of dimensions sufficiently large to receive the tunnel structure. In this channel are sunk steel tubes of the proper shape and dimensions, brought to true grade and alignment, and then encased in concrete, which extends underneath, around and above them in one monolithic mass. The tubes are then pumped out and lined.

This method was devised primarily for the purpose of eliminating the use of compressed air in constructing tunnels, and it thereby also eliminates the danger and risk which is always involved in carrying on operations in compressed air.

Dredging for Tubes.—The bottom of the Harlem River at the intersection of Lexington Ave. is composed of a soft silt for a depth of some 15 ft.; then it changes generally into sand which further down changes again into sand and gravel packed together fairly hard. In spots it was found to be so hard as to make dredging rather difficult.

Several telephone and power cables crossed the river at the tunnel site, and these had to be removed and relocated before dredging could proceed.

In order to facilitate the construction and comply with the requirements of the War Department, with respect to keeping open a navigable channel at all times, it was decided to divide the subaqueous section into five parts, or sub-sections, A, B, C, D and E. The dredging was done and the tube sections built and sunk in the order of the lettering.

Accordingly, the dredging of the trench was begun towards the middle of the river, working southward towards the bulkhead on the Manhattan side, completing it for the sinking of section A first, then B, C, D and E; section D being the most northerly one (tying up with the approach on the Bronx side), and section E the most southerly one (connecting with the approach on the Manhattan side). The trench was dredged to a width of 81 ft. at the bottom, with side slopes of approximately 1:1. These slopes would vary a great deal according to the nature of the material. In places they would be considerably steeper than 1:1 and in other places as flat as 2:1, and even more.

The material showed very little tendency to cave in, and, although the Harlem River is a tidal stream, the current consequently changing direction four times every 24 hours, still the tendency of the trench to fill up was imperceptible. The depth of the trench varied from about 35 ft. at the middle of the river to about 61 ft. at the banks. The total amount dredged out for the tunnel proved to be 274,000 cu. yd., while the estimated amount based upon 1:1 slope was 272,000 cu. yd., thus demonstrating that the assumption of 1:1 as an average for the whole tunnel was very nearly correct.

Launching of Tube Sections.—The 220-ft. sections when completed, ready for launching, weighed (steel, lumber and all about 770 tons. In order to launch this mass nine flat boats, 14 ft. 3 in. wide, 80 ft. long, and 5 ft. 2 in. deep, were floated in at low tide under the tubes between the rows of piling in the slip. They would just clear the diaphragms, the height of the falsework being so arranged.

With the rising tide the boats would bear up against the diaphragms of the tubes, and as the tide continued to rise they would gradually take the weight of the tubes off of the ways; at high tide the tubes would be entirely clear. They were then pulled out of the slip into the river by tugs, after which the boats were scuttled by opening valves provided for the purpose; they were sufficiently filled with water in about 15 minutes to cause the tubes to settle down and float on their own bottoms. The boats on one side generally filled a trifle faster than those on the other, causing the superimposed tubes to roll gently over until caught up by their own buoyancy and then roll back again until all four tubes floated level. The flat boats were then pulled out and the tube section was ready to be towed down to the tunnel site and sunk.

In towing the tubes they had to pass through three drawbridges with clear openings of only from 10 to 20 ft. more than the width of the tube section; this was accomplished, however, safely and without mishap in every instance.

Provisions for Sinking Tubes.—To sink a tube section, and at all times have it under complete control, it was provided with four steel air cylinders 10 ft. 6 in. diameter and 68 ft. 3 in. long. These were mounted crosswise on top of the tubes between the first and second and the third and fourth diaphragms from each end of the tubes. These air cylinders were built of 5/16-in. steel plates, the ends being dished. Each cylinder was divided into a center and two end compartments, the center compartment being 17 ft. 8½ in. in length. Each end compartment was provided on top with a 4-in. globe valve connected to a 4-in. pipe leading to within 1½ in. of the bottom of the cylinder and by means of which the end compartment could be filled or emptied as might be desired. To this end each compartment was further provided with a 2-in. valve by means of which, through a hose, air could be forced in for the purpose of emptying the compartment of water.

The center compartment was likewise fitted with a 3-in. globe valve attached to a 3-in. pipe reaching to within 1½ in. of the bottom; it also had a 2-in. valve by means of which a hose could be attached and air forced into the compartment. The center compartment was further equipped on the inside at the bottom with a 3-in. valve, which was operated from the top of the cylinder by means of a rod passing through the shell, fitted with a stuffing box for the purpose and ending in a hand wheel. By this valve water could be let into the center compartment for the purpose of adjusting the buoyancy of the cylinders.

The air cylinders were braced internally by angles spaced radially and riveted to internal stiffening angles. At the two points where each cylinder was attached to the steel tubes the bracing was made in the form of a diaphragm plate extending clear across and from the top down to 8 in. below the center of the cylinder. This diaphragm plate was in turn stiffened by angles. At these points a 12 × ⅝-in. steel plate was strapped around the cylinder and connected by means of equalizers to two hanger rods at each end, 1¾ in. square, which in turn were attached directly to connections provided on the diaphragms of the tunnel tubes next to the cylinders. These connections were designed so that a diver could easily disconnect them.

The buoyancy of the four cylinders amounted to 722 tons, while the weight of a section when submerged in water was about 646 tons, this being the exact weight of section A. Accordingly, the air cylinders had an excess buoyancy of 76 tons, which enabled the whole mass to just keep afloat when the tunnel tubes were filled with water; the back of the air cylinders would show only a couple of feet above the water's surface.

Before a section was sunk in place the bottom was prepared to receive it in the following manner: A series of frame bents were built. These consisted of two spuds of 12-in. square timbers, about 8 ft. long, pointed at the lower end and spaced 8 ft. apart; at the upper end there were framed in two 12-in. channels, 10 ft. long, bolted to the spuds with the channel flanges inwards and with the web plates coming flush with the spud. Five of these bents were driven in the bottom of and across the trench at a point so that the last diaphragm of the section would rest on the five bents which came at right angles to same.

The bents were driven by means of two floating piledrivers, with a follower placed directly over each spud. The follower was made of a steel column, and the bents could be driven to the exact level desired by leveling from shore to the follower.

The first section sunk was provided with a series of these bents under the last diaphragm at each end. For subsequent sections the bents were only used at the extreme end, the other end hanging in the pilot pins of the adjoining section until the connection was bolted up.

Sinking Operations.—When everything was ready for sinking the section was moored approximately in a position directly above its permanent location in the trench, between the concrete mixing scow on the one side and a derrick scow on the other. Suitable pile clusters were driven in such locations as to protect the section from passing river craft, and also to serve as anchorage for the tubes during the sinking. Tackles were attached to these pile clusters and to the section on both sides with their hauling parts leading to engines on the scows alongside so that the section could be manipulated sidewise or endwise as the need might be. When everything was ready the inlet valves were opened, and the water gradually filled the outside tubes. As previously stated, the valves were used for this purpose for the first section only; for the remaining sections a plank, or two, was sawed out of the low bulkheads of the center tubes, so that the water could flow into the latter. As soon as these were submerged the water could flow freely into the center tubes for their whole width and from the center tubes into the outer ones through holes provided in the timber bulkheads in the access openings. The outer tubes controlled the sinking, that is, the section could not sink any faster than these tubes would fill with water.

To permit the escape of air from these tubes a 3-in. hole, with nipple, was provided in the roof of the steel shell immediately back of each semi-bulkhead. A 2-in. hole, with nipple, was similarly provided right back of the end bulkheads; to the nipple was attached a 2-in. pipe long enough to extend above the water. This pipe had an air-control valve at the extreme end. When the tubes were half filled with water, the air between the end bulkheads and the semi-bulkheads would be trapped, and the water could not enter the tubes any faster than the escape of this air permitted. The object of this arrangement was to prevent the tubes from plunging endwise when about two-thirds filled, until the tubes were sunk so far that the air cylinders on top commenced to take effect; after that there would be no danger of plunging. The nipples mentioned were capped before concreting was commenced.

When entirely filled the tubes were suspended from the air cylinders which had an excess buoyancy of 76 tons. To lower the tubes the remaining distance to the bottom of the trench; the center compartments of the air cylinders were filled with sufficient water to overcome this buoyancy, and a trifle more. Before this adjustment took place, however, each end of the section was attached by a bridle and tackle to the boom of the floating derrick on one end and to the derrick on the concrete scow on the other, for the purpose of holding the section back. The load on the derrick line only amounted to as much as the excess of water let into the air cylinders beyond what was necessary to overcome their remaining buoyancy. This load never amounted to more than two tons. After the section was thus hung in the derricks it was lowered into position in the bottom of the trench by slacking off the derrick lines, only the four ends of the masts being visible. The position of the section was then adjusted laterally, vertically, and longitudinally to within half a foot or a foot of its correct position. This could be done by eye, because the previous section sunk was also provided at the extreme end with masts extending above the water level.

When approximately near the true position the section was simply pulled towards the section previously sunk and automatically found its way home. This was accomplished by the point of the pilot pin striking the funnel shaped socket of the other section and then sliding off until it entered the narrow end of the socket. Figure 2 shows details of the pilot pin and socket. The play between the pin and the socket was only ⅜ in. at this point. A diver then inserted the key in the slot of the pilot pin back of the socket, thus locking it in position. This end would thus hang supported by the pilot pins until the diver had completed the bolting-up of the connection. The outer end of the section rested lightly with its last diaphragm on the bents, and this end was checked for level and alignment by the means previously mentioned. The bolting-up required only about a day.

As stated, the diaphragms extended below the steel shell 2 ft. 3 in., and the bottom of the trench as left by the dredge was from 1 to 2 ft. below the diaphragms so that the bottom of the steel shell rested in a position approximately 3½ to 4 ft. above the trench bottom, which space was filled with concrete to form the foundation of the tunnel.

The first section was taken from its moorings, towed a mile (passing through three draw bridges) to the tunnel site, filled with water, lowered into position and located correctly to grade and alignment, in the space of nine hours. The same operation for subsequent sections required from four to six hours. The filling of the tubes consumed about one hour, another hour being required to admit enough water into the air cylinders to overcome their excess buoyancy.

Concreting Operations.—As soon as a section was sunk and the connection to the adjacent section bolted up, the work of encasing the steel shells with concrete was commenced. For this operation a special floating plant was constructed. A scow 33 ft. wide and 140 ft. long was rigged up along its side with five wooden towers, 6 ft. 6 in. square and 50 ft. in height. On the face of each tower there was operated a tremie pipe, 12 in. in diameter and 65 ft. over all, the upper end of which ended in a 4-ft. square hopper. The tremies and hoppers were rigged so as to move up and down on the face of the tower. They were spaced at such a distance apart that when the scow was moored crosswise of the tunnel section ready for concreting a tremie could enter each of the 2-ft. spaces between the steel tubes and the space between the outer tubes and the wooden sheeting on the sides. The lower end of the tremies reached the bottom of the trench when the hopper at the upper end was at the deck of the scow.

Three 1-cu. yd. concrete mixers were used for supplying the five tremies with concrete. One was located immediately back of the center tremie, and it supplied this one only. The other two were placed directly behind and half-way between the outer tremie and the one next to it, supplying both alternately. The concrete was passed from the mixer by chutes into 1-cu. yd. hoist buckets, which traveled vertically inside of each of the five towers and directly behind the tremie in such a position that when the bucket reached the tremie hopper the latter would trip it automatically and discharge the contents into the tremie.

Each concrete mixer was equipped with a sand bin of about 18 cu. yd. capacity and with a gravel bin of about 22 cu. yd. capacity. A cement room was provided, with storage for about 1,500 bags of cement. A cement platform was also provided at such a height as to permit dumping directly into the charging hoppers of the mixers. The concrete scow was also equipped with a derrick, a 2-cu. yd. clam-shell bucket, and a three-drum hoisting engine. This derrick was used for the purpose of unloading sand and gravel from scows, moored alongside, into the hoppers. Another three-drum hoisting engine and one two-drum engine were used for operating the hoisting buckets that fed the tremies. Each tremie was raised and lowered by an individual engine bolted to the back of each tower and operated by men stationed on the hopper platforms; it was the duty of these men to raise or lower the tremies as occasion required. The concrete scow was further equipped with a small air compressor and receiver and also with a small pump. Steam was supplied from one 120-hp. and one 50-hp. boiler. This concrete mixing plant was of sufficient capacity to fill one pocket containing about 475 cu. yd. of concrete in a shift of eight working hours.

In beginning the operation of concreting the scow was moored in such a position as to place the tremies, when lowered to the bottom of the trench, about in the middle of the pocket, one tremie for each of the two side and three partition walls. The tremies were then filled with concrete, which drove the water out, and as the tremies were raised in the leads freshly mixed concrete was dumped into the tremie hopper as fast as it ran out at the bottom. As soon as a surface of concrete was formed the mouths of the tremies were always maintained below this surface so that the concrete fed through the pipes always discharged within the mass, without coming in contact with the water in the river. The concrete flowed out laterally in a continuous stream within the confines of the pocket, filling the space between the tubes and the bottom of the trench; then rising it formed the sides and partition walls and the roof of the tunnel, the mouth of the tremies at all times being buried from 2 to 6 ft. in the soft concrete. When a pocket was nearly filled the tremies were moved about so as to insure the complete filling of a pocket at all points. Divers were used to see that this was properly done.

The exterior concrete was mixed in proportion of 1 part cement, 3 parts sand and 6 parts graded 1-in. gravel. For the first four sections of the tunnel the concreting was carried on up to the diaphragms only, until the whole bottom was thus concreted in and then each pocket was filled to the top, one after another until the section was completed. For section E (the last one), however, the filling was always done in one operation from the bottom of the trench to the top of the pocket, the concrete in this section being mixed in the proportions 1:3:5. The decrease in gravel, resulting in a relative increase in mortar, caused the concrete to flow more evenly through the tremies. The concrete between the bottom of the trench and the underside of the diaphragms was proportioned 1:4:8: This lean concrete was used because it was only necessary to replace the dredged material with something equally good.

As soon as a section had three or four pockets filled, sufficient to give it support on the bottom, the air cylinders were removed and used over again in sinking the next section. This removal was accomplished by first filling them with water (through the valves previously described), which then caused them to rest on the tubes without any stress in the hangers by which they were attached. The divers then disconnected these hangers, and as soon as the water was blown out of the center compartment the air cylinders rose to the surface and were thereupon emptied of the water in the end compartments.

The joint of two adjacent tube sections always came in the middle of a pocket, the diaphragms being spaced accordingly. The concrete in this joint pocket was made richer, the proportions being 1:2:4. The object of this was to secure a tight joint, as no other means were employed for this purpose until the tubes were pumped out and the joint plate bolted to the Z-bar flanges, and then grouted. The joints proved remarkably tight. The total quantity of exterior concrete in the tunnel was about 40,000 cu. yd.

Lining of Tunnel.—At the northerly end of the tunnel, near the full pressure bulkheads, there was provided an access shaft for each tube; these shafts were attached to the tubes before sinking and they reached about 4 ft. above high tide. They were 3 ft. in diameter and were made of ¼ in. plate. Through them the tubes were pumped out with ordinary pumps, as soon as the last concrete had thoroughly set, that is, when it was about three weeks old.

As soon as they were unwatered the tubes were lined with concrete. This lining is 15 in. thick, except along the vertical partition walls, where it is 12 in. thick and in the invert, where it is 2 ft. 10 in. thick at the center. The clear distance inside of the lining, between the roof and the invert, is 14 ft. 11 in., and the clear width between vertical walls is 13 ft. The vertical walls of the lining, besides being tied together by the bolts and yokes previously described, were reinforced with 1-in. square rods, spaced 12 in. on centers, bent to an arch and placed so that the rods would clear the vertical steel shell by 1½ in. and also come the same distance from the inside face of the concrete where the vertical walls joined the roof and the invert. Rods, ¾ in. square and spaced 2 ft. apart, were placed longitudinally in the lining.

The concrete in this lining was mixed in the proportions 1:2:4. The invert was put in place first up to the underside of the nest of electric conduits. The sides and top of the lining were placed in one operation, in 30-ft. sections, using movable timber concrete forms, 30 ft. in length, for the purpose. One such form was filled with concrete in a shift of eight hours. The forms were partly collapsible, and could be moved ahead intact, using a traveler for the purpose. The total amount of concrete in the lining was 12,500 cu. yd.

Approach Connections.—Simultaneously with the lining of the four sections A, B, C and D, the land connection at the north, or Bronx, end was made. A cofferdam was built of steel sheet piling with earth embankment on the outside. The steel sheet piling was simply an extension of the regular sheet piling used in constructing the approaches which were built in the open. The sheet piling was held apart by waling pieces and braces. To connect the steel sheet piling with the steel tubes half a width of sheet piling was riveted to the vertical edges of the last diaphragm, this being long enough to reach above the water level. This furnished a groove for the first regular piece of steel sheet piling to be driven. To the top flange of the last diaphragm there was riveted a plate with angles in the form of a channel laid flat, forming a groove in which the vertical timbers presently mentioned were fitted. A frame work, consisting of uprights and waling pieces, was fastened to this last diaphragm before the section was sunk. When the section was concreted in, this frame work was filled in with a solid wall of vertical timbers when reached above the water level and across the width of the tunnel, connecting the steel sheet piling on both sides and forming the third wall of the cofferdam, the fourth wall being the river bank itself. An embankment of selected material was filled in with approximately a 1½:1 slope outside the dam, to give it stability and make it tight. After the dam was completed the water was pumped out, and, as the water receded, braces were put in crosswise and diagonally to hold the walls against collapsing from the outside earth and water pressure. This cofferdam was about 60 ft. deep, and it proved very satisfactory. The approach connection at the Manhattan, or southerly, end of the tunnel was completed in a similar manner.

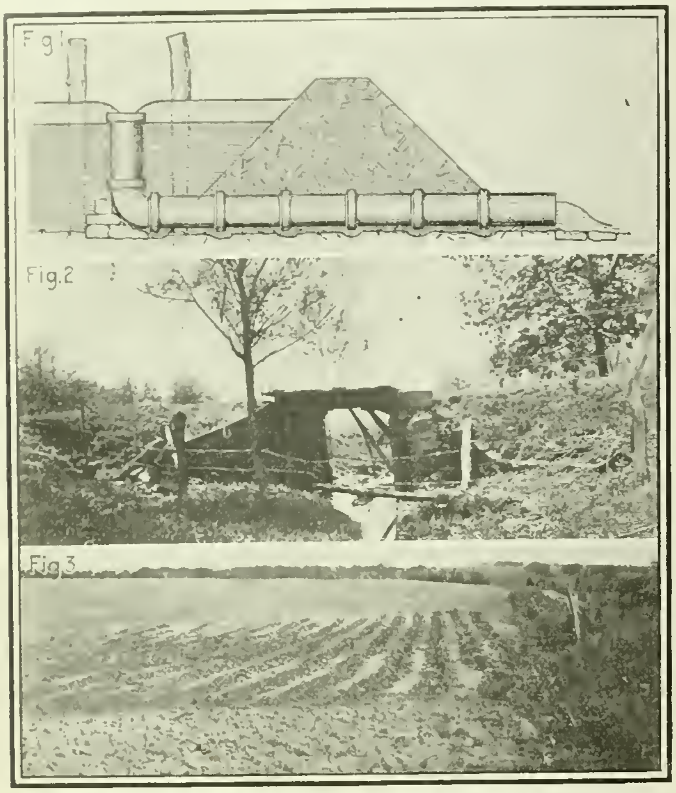
The river was completed without the loss of a single life and without any accident causing permanent injury to any worker.

Personnel.—The work was carried out under the direction of the engineers of the Public Service Commission of New York City; Alfred Craven, chief engineer; Robert Ridgway, engineer of construction; Svrre Dahm, principal assistant engineer; C. V. V. Powers, division engineer; J. P. Locke, assistant division engineer; and H. B. Gates, assistant engineer. The contractor for the work was the Arthur McMullen & Hoff Co. of New York City; N. R. Melvin, superintendent; G. A. Graham and G. Muller, assistant engineers, and the writer consulting engineer.

Miami Valley Flood Protection Project.—It is probable that actual construction on the Miami Valley Flood Protection Project will not be started this year. The Conservancy Court has postponed until Oct. 3 the date for hearing objections to the official flood protection plan, and it is likely that these sessions will extend into November. In the meantime, however, the appraisement of property throughout this district will continue, and abstracts of title to condemned properties will be examined and prepared. The remaining engineering work, also, will be pushed forward with all possible speed.

Current Engineering Practice Briefly Recorded

A METHOD OF PREVENTING SOIL EROSION.



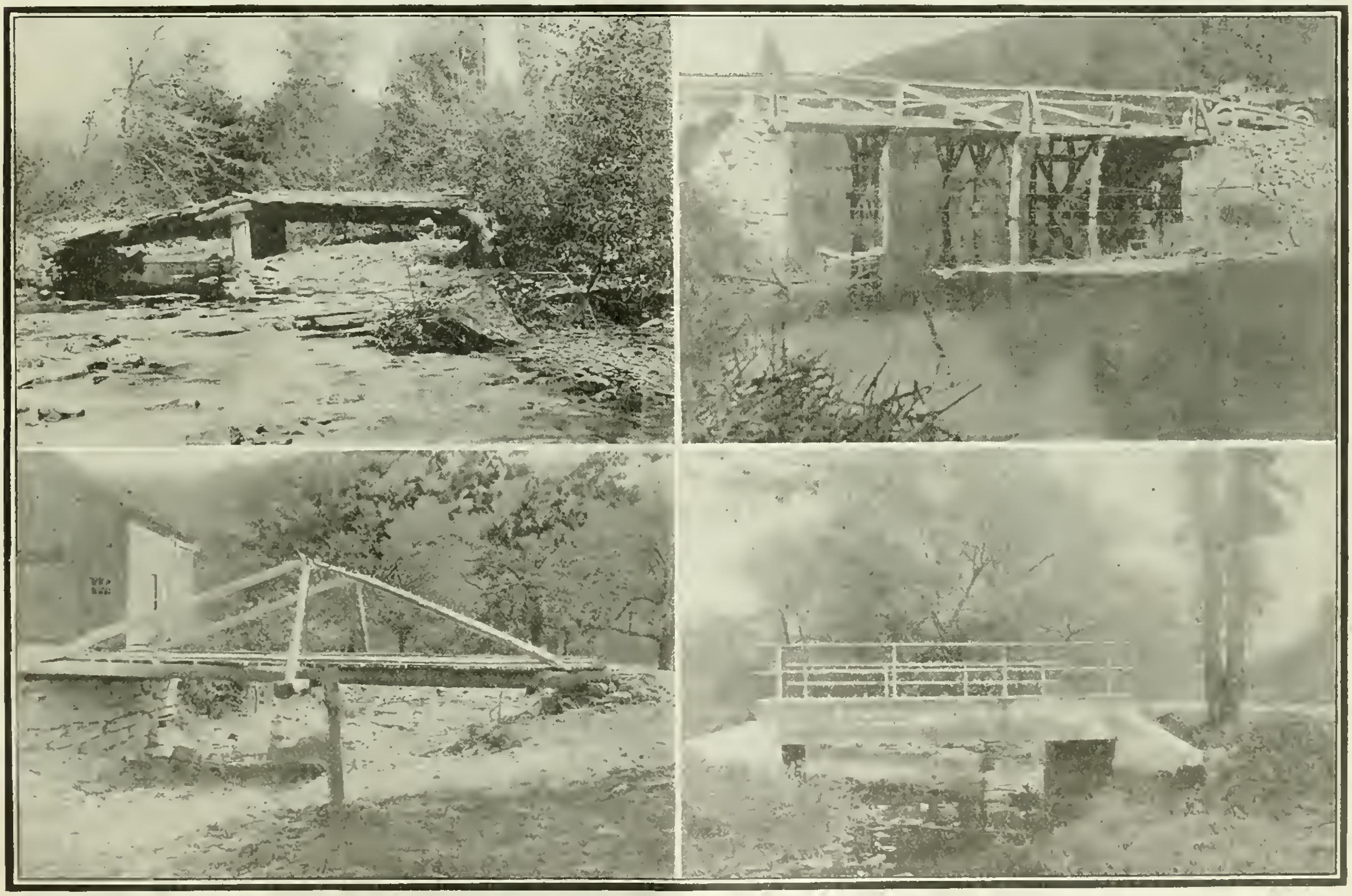
Three illustrations which demonstrate very clearly the worth of a simple method of preventing soil erosion are furnished in a paper by Benjamin Brooks before the Iowa State Drainage Association. Selecting typical conditions the paper refers to farmers along the south bank of the Missouri River, saying: Their farms lie in a hill country with very light soil some miles back from the main stream, but drained by small tributaries. These men have been through the whole gamut of experience, starting with smooth, grass-covered farms, plowing the grass under, loosening the soil and having it wash away from them, leaving only deep, ragged gullies and mortgages; then having to devise their own means of retaining what soil was left and refilling the gullies with it. To accomplish this they worked on two main principles of soil conservation, which they discovered slowly and by bitter experience. They found out what every civil engineer knows, that running water caught in the act of robbing a farm of its soil, can be arrested in a pool long enough to drop its loot and go on empty handed. Their method of arresting it is simply to throw earth dams at intervals across the gullies; but, in order that the dams shall not be overflowed and washed out, they provided each with a by-pass pipe underneath and a suitable riser made of ordinary clay sewer pipe, so that the water pooled and rose to the height of the by-pass, dropped its soil, and ran off comparatively clear. As the gully filled up with this deposited soil they raised the dam and added more sewer pipe to the riser until the entire gully became a flight of smooth terraces instead of a hole in the ground. The other principle they discovered is also well known to us—the fact that water, soaking slowly down through soil and out through sub-drains will cause no erosion; while the same amount of water coursing over the surface will cause it. Accordingly, some of them laid clay drain tile along the bottoms of the gullies and filled in over them. Sometimes they combined the two ideas, throwing low dams across the filled gullies and connecting a riser pipe with the drain below. They went so far as to get the county supervisors to allow them to take out their old wooden culverts which let soil and water alike go by, and to put in soil saving sewer pipes wherever a bad gully crossed a country road.

JOINT CONSTRUCTION EASTON-ALLENTOWN CONCRETE ROAD, PENNSYLVANIA.

The road indicated is 21 miles long from Easton to Allentown, Pa., and is being constructed by force account by the Pennsylvania Highway Superintendent, William D. Uhler, Chief Engineer.

The transverse joints were made by tying two 9-in. x 16-ft. strips of ⅛-in. Elastite to a 9-in. x 16-ft. steel plate, the assembled joints being placed across the pavement perpendicular to the subgrade, at right angles to the center line of the road and 39 ft. 6 in. apart, with the Elastite next the section being finished. Concrete was placed on both sides, that on the Elastite side being struck off, the strings cut and the plate pulled out by its handles. After the concrete had set 24 hours, the Elastite was trimmed off ½ in. above the finished section of concrete. The concrete at the transverse joints was floated with a double float, allowing the Elastite to pass through the center of it and thus producing a smooth, even finish on each side of the joint. The edges of the concrete at the sides of the road and at the transverse joints were beveled with steel edgers so as to eliminate chipping. A 2-in. radius edger giving a ¾-in. bevel was used at the sides in a 1-in. radius edger giving a 3/16-in. bevel was used at the transverse joints. The floating and edging was not done until the surface of the concrete had a glossy appearance. After the floating had been completed and the concrete sufficiently set, the forms were removed, generally in about 18 hours.

Under a very hot sun, the finished concrete was protected by canvas covering supported by wood frames to prevent the canvas from touching the concrete. The finished surface of the pavement was sprinkled with water as soon as the concrete had set sufficiently to prevent pitting, and was kept wet until a 2-in. earth covering could be placed without damage to the concrete. This earth covering was kept wet for a period of ten days and after fourteen days it was removed and placed on the berms where needed, and all excess disposed of.



During this curing period, when the temperature dropped in the daytime to 50° Fahrenheit, the pavement was sprinkled occasionally, but not covered with earth. All traffic was kept off the finished pavement for 28 days.

FOUR HIGHWAY BRIDGES.

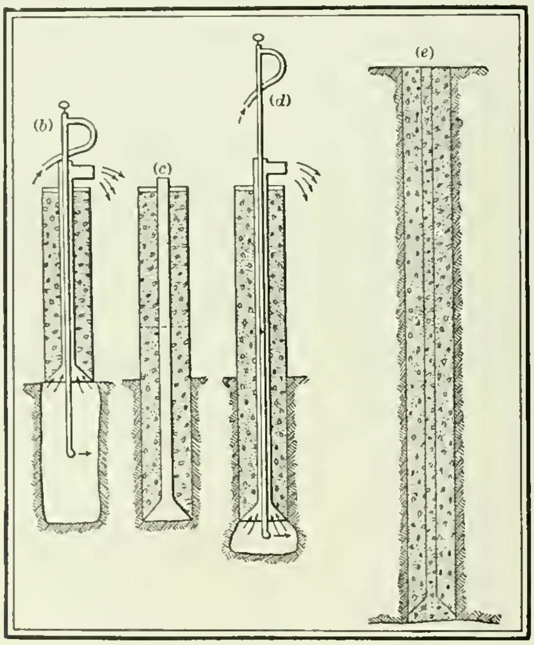
The four pictures of highway bridges shown accompanying were disinterred from an abandoned editor's desk. Whence and why they came were once known precisely doubtless, but the knowledge has vanished with the editor. Being securely "clipped" together when found one surmises a common origin. Why they were buried one can only speculate. Perhaps the editor perceived no vitality in them, perhaps interment was accidental, perhaps the editor faring forth with his eyes set on the greater greenness of far fields callously forsook his charges. Whatever the reason for burial, they are now unsepulchered and exposed to the vision of the curious. Our reason for thus violating the grave are two: The views are picturesque. They depict the modern and an older era in highway bridge building. To the engineer whose work spans some portion of both eras they tell more than could be told in many words of the change that is coming over the land in matters of highway engineering. If these pictures show that anything of the picturesqueness of country roads is disappearing in the change let us content ourselves with the certain evidence which they present of increased country road serviceability.

DISPLACEMENT METHOD OF DETERMINING WEIGHT OF STONE IN VESSELS.

In the "displacement" method, a displacement volume of the vessel is obtained well outside the maximum and minimum limits, which reduced to weight gives a mass curve from which loads can be directly taken. The procedure is as follows: The draft marks of a vessel are taken at the stem and stern loaded and again when lightened and pumped out. In the latter condition the vessel is measured, an operation which occupies about an hour after men have become accustomed to taking measurements. The length is taken horizontally on deck, forward of the after part of the stern post, which is called station zero, to a point just forward of the loaded mark on the cutwater, the length being divided into stations of 10 ft., and at the bow, sometimes, of 5 ft. At these stations the semi-widths are obtained to the outer edge of the rail, and then at each succeeding station offsets from a plumb line, hung from the rail by means of an outrigged stick so that the line just touches the side of the hull at the widest part of the section, are taken to the side of the hull at each even foot above light water line, the plumb line being tagged every foot. These measurements are taken as carefully as possible horizontally and normal to the axis of the vessel; and the distance subtracted from the semi-width at the rail plus the distance to the plumb line from the outer edge of the rail gives the semi-width of the vessel at each even foot plane above light water line for each station. After measurements are taken at all stations, the slant of the cutwater and sternpost is obtained in the same manner. Each station section taken as above is plotted on cross-section paper and a curve faired through all the points, which is taken as the mold of the hull at that station for the distance displaced. From these sections distances are taken and a horizontal section of the hull plotted for each foot above light water line. These areas are then planimetered and the volume for each foot computed and plotted as a curve. In determining the cargo carried by a vessel, the mean of the bow and stern displacements is read off the curve, giving the tons directly. In computing the weight, that of sea water is assumed as 64.2 lb. per cubic foot and tons are obtained in units of 2,000 lb. This method, described by A. S. Ackermann, was employed in the Cape Cod Canal breakwater construction.

STEEL CONCRETE CYLINDER PILES FOR REPLACING A DEFECTIVE FOUNDATION.

Settlement of a building founded on soft ground overlying a deep cemented gravel stratum was checked and the foundation made stable by the method described as follows by W. R. Phillips in Proceedings, American Society of Civil Engineers, Vol. XLII, p. 713: The method adopted for supporting the buildings, and which resulted in finally cutting away and abandoning the original foundations, was to sink concrete piles, in pairs on each side of the old foundation walls, to a bearing on the cemented gravel, and to support the walls and piers on reinforced concrete beams carried by the piles.



The pile as used consists of an outer shell of steel plate attached to an entering piece called the "point," and an inner tube also attached to the point, the space between the outer shell and the inner tube being filled with concrete. The "point" may be considered as a continuous circular gouge with a cutting edge. On the inside, from the cutting edge upward, there is a short conical piece which is also connected to the inner tube and forms an inverted funnel of which the inner tube is the spout. The work connected with sinking the pile is done through the inner tube.

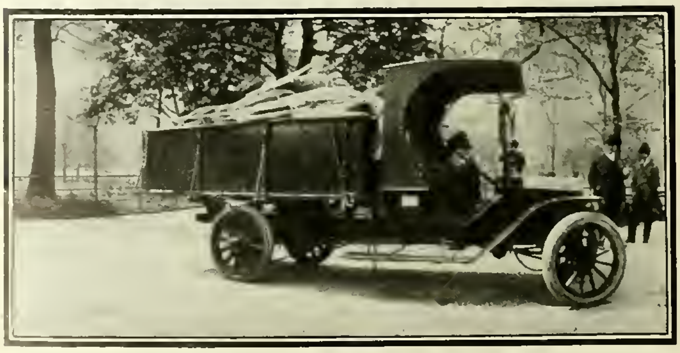
In its application, the "point" and a section of shell of convenient length is set in position, with a guide-frame around it to start it straight in its descent, the annular space inside the shell being filled with concrete. A pipe, which may be moved vertically or rotated at will, with a nozzle which will throw a jet of water horizontally, is inserted in the tube and connected with a pressure system by a hose or other device. Manipulation of the jet bores a hole of sufficient size into which the pile may settle, the material thus removed passing upward and out with the water, by way of the inner tube. When this first section of the pile has reached a level in sinking that makes it necessary to lengthen it, courses are added to the shell, the tube is extended, concrete is placed, and sinking is resumed. The process of extension is repeated until the pile has reached the required depth, and then the space beneath is washed out and it and the tube are filled with concrete. A total of 153 piles from 22½ in. to 30½ in. in diameter and from 108 ft. to 112 ft. long were sunk.

ADDING MACHINE USED BY PRECISE LEVELING PARTIES.

An adding machine is now being used by precise leveling parties of the U. S. Coast and Geodetic Survey for recording observations. The machine used is of the listing type, and the recorder puts on the keys the reading of the rod as called out by the observer. The machine has 10 banks and adds to 10 places. The four banks on the left side are used for recording the back sights and the four on the right hand side for the fore sights. Upon the completion of the observations on a section of the line the recorder adds the numbers listed by pulling the lever, and the difference between the sums of the back sights and the fore sights gives him at once the difference in elevation between the two bench marks at the ends of the section. The adding machine is fastened to the motor velocipede on which the recorder moves from station to station. According to the Coast Survey Bulletin the use of the machine has saved considerable time and expense. The necessary notes in regard to the location of the work and the direction of running, weathers conditions, etc., are made on the roll used to list the observations and the roll forms the original record of the observations.

MOTOR TRUCK SERVICE SUCCESSFUL IN NEW YORK CITY PARK DEPARTMENTS.

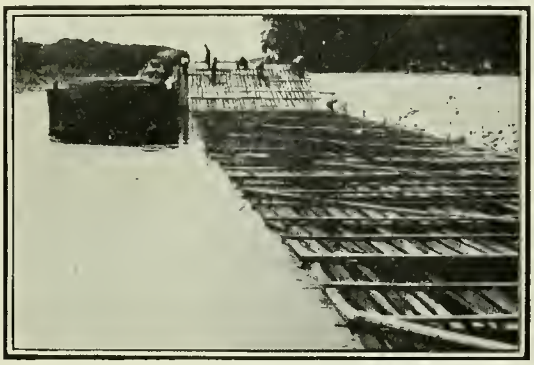
An annual saving of $50,000 is estimated from motorizing all the vehicles of the Park Departments of Manhattan and Richmond Boroughs in New York City. In a special report Commissioner Cabot Ward said he had substituted four automobile trucks for fourteen single horse carts, four shop wagons, and four two-horse teams. The fourteen carts had been operated at an annual expense of $1,160, of which $912.50 was for drivers' salaries; $182.50 for forage; $40 for shoeing, and $25 for incidentals. The four double horse teams had been operated at an expense of $1,003.75 for drivers' salaries; $365 for forage; $80 for shoeing, and $40 for incidentals—a total of $1,488.75 each. In making his estimate of the saving effected by substituting the four automobiles for the twenty-two wagons and carts, Commissioner Ward made an allowance of one-half of the cost of the automobiles for depreciation during the first year of operation. This depreciation allowance is from 75 per cent to 150 per cent above the general municipal experience in automobile service. The motor vehicles which replace the 22 wagons and carts consist of two Ford trucks, with special dump bodies for rubbish pick-up work; one Buick, with an express body, and one 3½-ton heavy dump automobile truck, for carting sand, gravel and manure. The total cost of these automobile vehicles was $6,428.85; the salaries of four chauffeurs amount to $3,800 annually, and motor supplies cost $2,940.60 additional. The old carts and wagons were turned over to the Sinking Fund for transfer to other city departments on a basis of a valuation of $4,000, so that allowing half the cost of wear and tear on the automobiles as a proper depreciation charge the city actually gains $1,000 in equip-



ment in addition to the saving on salaries and supplies by making the change from horse to motor in the department.

COMPARATIVE COST OF BOARD MAT AND BRUSH MATTRESS FOR RIVER BANK PROTECTION.

The illustration shows the construction of board mat for bank protection in the upper Mississippi River. As fully described in our issue of Aug. 13, 1913, these mats, made of all lumber and used much as brush mattress, have long been used and have gained increasing favor since the first experimental work in 1911. In 1915 records were kept by the U. S. Engineer Office at Rock Island, Ill., of board mat and brush mattress construction, which, as recorded by Assistant Engineers E. Edwards and Robert Iakisch, are of particular interest. The average quantities required per square (100 sq. ft.) of apron mat were: 66 ft. B. M. lumber, or 4.8 cu. yd. of brush. In other words, 13.75 ft. B. M. lumber was equivalent to 1 cu. yd of brush. The cost of material (on barges) was: Lumber, $11.95 per M ft. B. M. and brush, $0.24 per cu. yd., making the initial cost per square, $0.789 for lumber and $1.152 for brush. During the same season, it was found that eight laborers could construct an average of 120 squares (12,000 sq. ft.) of lumber apron mat per day, while with brush the average was 75 squares (7,500 sq. ft.) per day. The best day's work with twelve laborers was 180 squares of lumber mat. There was used in bank revetment work in this division during 1915, 136,206 ft. B. M. of green cull lumber, made up of elm, willow, cottonwood, etc. This amount was carried on two standard barges (100x20x5 ft.), whereas the average barge load of brush is about 400 cu. yd. Using 13.75 ft. B. M. lumber to 1 cu. yd. of brush, the above 136,206 ft. B. M. of lumber would be equivalent to 9,905 cu. yd. of brush, which would make approximately 25 barge loads. The cost of towing the above amount of lumber was $40, or about 30 ct. per thousand. The cost of towing the equivalent in brush fascines at 4.2 ct. per cubic yard was $416, which shows a large percentage in favor of lumber. Owing to the greater buoyancy of a brush mat, it requires more than twice as much rock to anchor it safely on the bottom. The average amount of rock used to sink a square (100 sq. ft.) of apron mat was: For lumber, 0.77 cu. yd.; for brush fascines, 1.70 cu. yd. The following tables give the comparative costs of lumber and brush fascine apron mats for season 1915:



COST OF BRUSH FASCINE MAT, 1,000 FT. LONG, 30 FT. WIDE (300 SQUARES).

Brush, 1,440 cu. yd. at 24 ct.	$ 345.60
Rock, 510 cu. yd. at 85 ct.	433.50
Towing brush, 1,440 cu. yd. at 4.2 ct.	60.48
Towing rock, 510 cu. yd. at 21 ct.	107.10
Labor constructing mats, 8 laborers 4 days at $1.75 per day	56.00
Labor sinking mat, 510 cu. yd. rock at 4 ct	20.40
Wire, 80 lb. at 3 ct.	2.40
Total	$1,025.48

COST OF LUMBER MAT, 1,000 FT. LONG, 30 FT. WIDE (300 SQUARES).

Lumber, 19,800 ft. B. M. at $11.95 per M	$ 236.61
Rock, 231 cu. yd. at 85 ct.	196.35
Towing lumber, 19,800 ft. B. M. at 30 ct. per M	5.94
Towing rock, 231 cu. yd. at 21 ct.	48.51
Labor constructing mat, 8 laborers 2½ days at $1.75 per day	35.00
Labor sinking mat, 231 cu. yd. of rock at 4 ct.	9.24
Nails, 4 kegs at $2.05 and 25 lb. wire at 3 ct.	8.95
Total	$ 540.60

The above shows a balance of $484.88 in favor of lumber mat (300 squares) or $1.62 per square.

SEWAGE TREATMENT WORKS FOR CITIES ON BOUNDARY WATERS.

Remedial measures for the present condition of pollution of certain boundary waters, calling for an expenditure of many millions of dollars, are suggested in a recently issued report of Earle B. Phelps, Consulting Sanitary Engineer of the International Joint Commission. The studies were confined to the St. Clair, Detroit and Niagara Rivers. Upon the two latter streams are Buffalo and Detroit, the two largest cities existing along the boundary rivers and these waters are accordingly by far the most seriously polluted. In these two cities the most important and difficult engineering problems are to be found. Feasible remedies developed in these two cases, therefore will be feasible in the smaller communities, while the advisability of remedies in the case of the latter will necessarily depend upon the advisability of a general policy of improvement determined primarily in the major city upon which the burden of expense must fall.

The studies were in the nature of preliminary engineering investigation of certain alternative projects of main drainage lines and treatment work. They were carried far enough, however, to develop feasible plans of collection and disposal at all important points in the three most seriously polluted connecting rivers and to determine the upper limits of cost of these improvements. The general type of treatment adopted, with suitable local modification, is essentially the same in all cases. It comprises coarse screening for the removal of large floating material, sedimentation in Imhoff tanks, with simultaneous chemical disinfection with chloride of lime. The necessary auxiliary plant, sludge drying beds, chemical mixing tanks, etc., also are provided.

The estimated costs of construction for the various localities are summarized in Tables I and II.

TABLE I.—SUMMARY OF COSTS AND ANNUAL CHARGES FOR SEWAGE TREATMENT, DETROIT DISTRICT.

City.	Population designed for.[1]	First cost.	Annual charges Fixed.	Operating.	Total.	Per capita.
Detroit, Mich.	950,600	$ 5,932,024	$294,901	$215,545	$ 510,446	0.54
	[2]2,631,350	12,905,350	635,616	525,545	[2]1,160,561	.44
Windsor District, Ontario	55,000	392,286	21,291	16,000	37,291	.68
	[2]110,000	779,187	40,868	25,000	[2]65,868	.60
Fort Huron, Mich.	25,000	291,135	15,781	9,000	24,781	.99
	[2]40,000	356,677	19,249	11,000	[2]30,249	.76
Sarnia, Ontario	16,000	100,250	5,414	6,000	11,414	.71
St. Clair, Mich.	3,000	28,063	1,620	1,200	2,820	.94
Marine City, Mich.	4,000	62,940	3,655	1,700	5,355	1.34
Algonac, Mich.	1,700	14,650	928	1,400	2,328	1.37
River Rouge, Mich.	15,000	63,635	3,204	4,500	7,704	.51
	[2]30,000	115,385	6,105	7,000	[2]13,105	.44
Ecorse, Mich.	4,000	23,078	1,331	1,400	2,731	.68
Ford City, Mich.	5,000	32,287	1,814	1,600	3,414	.68
Wyandotte, Mich.	16,000	68,560	3,911	5,000	8,911	.56
	[2]30,000	101,960	5,714	8,000	[2]13,714	.46
Trenton, Mich.	1,200	2,650	132	500	632	.53
Amherstberg, Ontario	3,000	17,056	1,079	1,300	2,379	.79
Total	1,098,900	......	......	......	$ 620,206	565

[1] For treatment. Interceptor designed for greater populations in practically all cases.

[2] These quantities excluded from the totals and general average per capita charge.

TABLE II.—SUMMARY OF COSTS AND ANNUAL CHARGES FOR SEWAGE TREATMENT, BUFFALO DISTRICT.

City.	Population designed for.[1]	Total first cost.	Annual charges Fixed.	Operating.	Total.	Per capita.
Buffalo, N. Y.	600,000	$3,598,751	$203,457	$187,411	$390,868	0.648
Tonawanda, N. Y.	11,500	70,685	4,241	6,650	10,891	.947
No. Tonawanda, N. Y.	18,000	130,166	7,451	8,900	16,351	.885
La Salle, N. Y.	3,500	38,648	2,320	1,500	3,820	1.091
Niagara Falls, N. Y.	69,000	525,950	30,730	28,457	59,187	.857
Niagara Falls, Ont.	18,000	83,637	5,108	8,960	14,068	.782
Lackawanna, N. Y.[2]	16,342	4,000	240	1,200	1,440	.088
Bridgeburg, Ontario[2]	2,110	2,000	120	500	620	.294
When needed.						
Fort Erie, N. Y.	2,000	13,600	816	1,500	2,316	1.16
Kenmore, N. Y.	2,500	10,000	600	1,500	2,100	.84
Chippewa, Ontario	850	28,050	1,680	520	2,200	2.59
Queenston, Ontario	300	4,300	258	500	758	2.53
Lewiston, N. Y.	900	5,600	336	500	836	.929
Youngstown, N. Y.	1,000	20,000	1,200	500	1,700	1.07
Total	746,002	......	......	......	$507,155	.68

[1] For treatment. Collectors designed as for population to be expected in 1950.

[2] Additional to existing treatment.

TRACING A DRAWING WITHOUT TRACING CLOTH.

Tracing cloth is affected by the amount of moisture in the air, and for that reason it is occasionally desirable to transfer a drawing to ordinary paper. This may be accomplished by the use of a glass top table beneath which are suspended several strong (60 to 100-watt) incandescent electric lamps. The strong light passes through the drawing and the superinposed paper on which the tracing is to be made. Where blueprints are desired a thin white paper can thus be used instead of tracing cloth and at less expense.

A 44-MILE HIGHWAY LETTING IN OHIO.

A good-sized highway letting will be held next week by the commissioners of Columbiana County, Ohio. The work calls for the improvement of 43.94 miles of roads, bids for which will be opened on the following dates:

	June 20.	June 21.	June 22.
Monolithic brick paving	7.45	5.50	1.4
Waterbound macadam	3.55	3.52	3.32
Bituminous macadam	4	8.10	..87
Grading and bridging	....	2.65	3.48

The work covers 24 contracts, the largest calling for an estimated expenditure of $100,007. This latter job provides for the improvement of a part of the Lisbon-Salem public road in Center and Salem Townships. It is divided into two sections of 17,983 ft. each. Section 1 will be surfaced with bituminous macadam, the estimated cost being as follows: 18,207 cu. yds. excavation at 38 cts.; 27,896 sq. yds. bituminous bound macadam at 98 cts.; bridges and culverts, $847. The second section will be paved with brick on concrete base, the estimates being as follows: 25,992 cu. yds. excavation at 38 cts.; 27,897 sq. yds. paving at $1.88; bridges and culverts, $2,580. H. C. Armstrong, Lisbon, O., is County Highway Superintendent.

PERSONALS.

Mr. W. F. Dozier, a civil engineer of Temple, Texas, has been appointed city manager of that city at a salary of $2,600 a year.

Mr. George B. Marshall, Superintendent of Road Construction, U. S. Office of Public Roads, has been assigned to the state of Texas.

Mr. Edward M. Stayton has been appointed County Surveyor and Highway Engineer of Jackson County, Missouri, to succeed Mr. A. C. Southern, resigned.

Mr. Howard S. Morse, formerly director of the Bureau of Municipal Research at Cincinnati, Ohio, has been placed in charge of the public works department of the new organized Bureau of Government Research at Detroit.

William V. Murray has been appointed superintendent of construction for James Stewart & Co., New York City, with headquarters at Bridgeport, Conn. He formerly was superintendent of construction for the State of Montana.

Mr. John S. Evans, Columbus, O.; C. L. Reamer, Columbus, O.; and Charles J. Ward, Newark, O., have been certified to the state highway commission of Ohio by state civil service commission as eligible for appointment to the position of assistant bridge engineer.

Arthur J. Hewitt of Milwaukee has been elected president of the Wisconsin Tunnel & Construction Co., which will engage in municipal sewer contracting and other construction work. The other officers of the company are F. H. Nakielski and Thomas Szukalski.

The Salt Lake Chapter of the American Society of Civil Engineers was organized on June 3, and the following officers were elected: E. C. La Rue, president; A F. Doremus, first vice-president; A. F. Parker, second vice-president; H. S. Kleinschmidt, secretary-treasurer.

Mr. E. E. Worthing has been appointed signal engineer of the Southern Pacific lines with headquarters in Houston. He will have charge of the construction and maintenance of automatic box signalling from New Orleans to El Paso. He formerly was Supervisor of Signals with the same lines.

Mr. William Walter Carson, a member of the faculty of the University of Tennessee since 1885, has resigned as Professor of Civil Engineering on account of advancing years and has been made Professor Emeritus Mr. Nathan W. Dougherty, heretofore assistant professor, has been appointed professor to succeed Mr. Carson.

The late Patrick T. Welsh, the contractor, left an estate of close to $2,000,000 according to the inventory filed a few days ago in the District Court. Of this amount personal property totaled nearly $1,500,000, while real estate and farm lands made up the remainder. In addition it is estimated that before his death he had made bequests amounting to over $1,000,000.

Mr Frederick E. Beek, for several years Construction Engineer of the Water Department of Binghamton, N. Y., has been appointed superintendent of the pumping station and filter plant. He will relieve Superintendent Moses Stoppard of a portion of his duties. The latter, however, remains Superintendent of Construction, having charge of all outside work.

Mr Cornelius F. Burns of Troy, N. Y., has been elected president of the Conference of Mayors and Other Officials of the State of New York Walter R Stone, Syracuse, N. Y., was elected vice-president: Joseph W. Stevens, Albany, treasurer, and H. Clayton Midlam Troy, James R. Cline of Amsterdam and Palmer Canfield, Jr., of Kingston, members of the State Municipal Bureau Council

The Board of Estimate and Apportionment of St. Louis, Mo., has ratified the appointment of Clinton H. Fisk as chief engineer of construction on the Municipal Bridge, at a salary of $5,000 per year. Mr. Fisk heretofore has been Assistant Sewer Commissioner, but has been practically in charge of bridge construction for some years. In addition to his work on the Free bridge he has had charge of a great deal of sewer building in the city and supervised the Mill Creek sewer construction.

The engineering and contracting firm of McMahon, Farrington & Baker has been organized and has opened offices in the Press Building at Binghamton, N. Y. Offices also have been opened at Owego and Elmira. Mr McMahon is a graduate of Union College and has had long experience in engineering design and construction on the Panama Canal and on several large municipal jobs in South America and Mexico. Mr. Farrington is a graduate of Cornell University and formerly was with the J. G. White Co., Consulting Engineers of New York City, on power plant construction at La Crosse, Wis., and with the Appalachian Power Co., as chief engineer on a transmission line through Virginia. The new firm has just started work on a $50,000 concrete paving job at Waterloo, N. Y.

OBITUARY.

Charles Beckwith, a well-known building contractor, of Western Massachusetts, died June 6, at his home in Pittsfield, Mass. He was a member of the contracting firm of Beckwith & Pike.

M. F. Ellis, a contractor of Atchison, Kansas, for the past 36 years, died in that city June 1, aged 67 years. Mr. Ellis is said to have made the first vitrified brick west of the Mississippi River.

Major R. M. Coburn, Assistant Engineer of the Seaboard Air Line Ry., with headquarters at Norfolk, Va., died June 1, at the home of his sister, in Beaumont, Texas. Major Coburn came to Beaumont the first of last month in the hope that the climate would benefit him.

Charles Sooysmith, M. Am. Soc. C. E., consulting engineer, died June 2 at his home in New York City. He was the son of the late Gen. William Sooy Smith of Chicago. He was 60 years old. He was a graduate of Rensselaer Polytechnic Institute and also spent two years in study in Europe. From 1879 to 1881 he was in the employ of the Santa Fe Ry. as Assistant Superintendent of Track, Bridge and Buildings. In the latter year he joined his father in the firm of Wm. Sooy Smith & Son., engineers and contractors. In 1887 he organized and became president of the firm of Sooysmith & Co., contracting engineers. This firm constructed many important railway bridges in the South and West. Mr. Sooysmith introduced the pneumatic caison method for sinking the foundations for high buildings. He also introduced in this country the freezing method for making excavations and greatly improved and developed it. He also perfected plans for its application in the driving of subaqueous tunnels.

NEWS LETTERS.

ST. LOUIS ITEMS.

J. J. Keeley of East St. Louis was awarded a part of the new Belt Line R. R. across the river the other day.

Mulvill Brothers of Alton, Ill., can use two small team outfits on force account work on the C. & A. R. R. in western Missouri.

M. C. Connors & Co., Chicago, Ill., have a drag line at work at Walkerville, Ind., loading gravel for the Wabash Railroad at that point.

Printy & Butler finished their levee work at Cummins, Ark. Have twenty-one good teams that they wish to place on railroad grading in the north.

Wm. Nuttal, representing M. C. Connors & Co., Chicago, Ill., came to town to bid on the Burlington spur at West Alton, Mo. Just a little too high.

Contractors in want of labor or work for their outfits write Koenig's Labor Agency, 612 Walnut street, St. Louis, or 503 Delaware street, Kansas City, Mo.

R. A. Dentzer, representing S. R. H. Robinson & Son, left here for La Mont, Ill. Dentzer reports their big job on the canal at that point as progressing along nicely.

Mulvill Brothers of Alton were awarded the contract for building a spur on the Burlington Railroad at West Alton, Mo. They have an outfit of thirty-five teams at work on the job.

J. W. Tracey, representative of District No. 1, International Brotherhood of Steam Shovel Engineers and Dredgemen, whose headquarters are in Chicago, spent a couple of days here on business.

L. J. Smith of the L. J. Smith Const. Co. of Kansas City was in and out of St. Louis a couple of times since last issue. Smith sold quite a lot of his blooded stock at the Kansas City show last week.

S. H. Fields, superintendent for A. L. Cook on the bank widening work on the M., K. & T. R. R., passed through St. Louis the other day on his way back from Chicago. Fields took back a lot of stationmen with him.

The Hercules Powder Company opened a new suite of offices in 1524 to 1528 Pierce building, St. Louis, to accommodate the representatives of the company recently moved to St. Louis from Joplin, Mo. In future the district manager's office will be located here in place of Joplin, Mo. The force moved to St. Louis consists of N. P. Rood, manager; F. A. Wilber, chief clerk; Courtland Scoville, Geo. J. Kensinger, Ella Osborne, Blanche Forsythe. The regular St. Louis force joining the Joplin delegation consists of T. E. Brogan, sales agent, Virginia Banks and Walter Hurley. Mr. J. H. Rood will remain at Joplin with a capable force in charge of the large business of the company in the lead and zinc mining district. The territory of the new St. Louis office extends from the Mississippi River to the Utah line, with branch offices at Joplin, Webb City, Mo.; Miami, Okla.; Denver and Cripple Creek, Colo.

A. B. KOENIG.

INDUSTRIAL NOTES.

The Terry Manufacturing Co, Grand Central Terminal, New York City, has been formed by Edward T. Terry to conduct the business of manufacturing cranes, derricks and structural steel formerly handled by the Terry & Tench Co., Inc. The business of the latter company, with the exception of that noted above, will be carried on as usual, the offices of both companies being continued at the Grand Central Terminal.

Alvan Macauley, vice-president and general manager, will be made president of the Packard Motor Car Co. This well-merited recognition of Mr. Macauley's successful handling of the company's business will be conferred by the board of directors at the request of President Henry B. Joy. Mr. Joy will continue to devote his energy to Packard affairs, and in the capacity of chairman of the board he will remain the chief guiding spirit of the institution. Mr. Joy is a director of the Wabash Railroad, is president of the Lincoln Highway Association and is identified with several important organizations of a patriotic character. Mr. Macauley was born in West Virginia. He attended college at Lehigh University and was graduated from the law school of George Washington University, Washington, D. C. He was admitted to the bar in the District of Columbia and in the state of Ohio. He has been prominently identified with three of the most notably successful industrial concerns in the United States—the National Cash Register Co., the Burroughs Adding Machine Co. and the Packard Motor Car Co. In 1895 he went to Dayton to be patent attorney for the Cash Register Co. When he left to become general manager of the Burroughs Adding Machine Co., six years later, he was one of the directing heads of the cash register business. He came to the Packard as general manager in 1910, but remained a director of Burroughs Company. Two years ago he was made vice-president and general manager of the Packard.

Engineering and Contracting

H. P. Gillette, *President and Editor*

Volume XLV. CHICAGO, ILL., JUNE 21, 1916. Number 25.

AESTHETICS AS AN ASSET IN WATER FILTRATION.

The operating room of a mechanical filter plant need be to serve all practical purposes, only a very plain and crude structure. Recent practice in filter plant construction, however, shows operating rooms with black slate tables, tile floors, white enamel walls, nickel fixtures, seats, potted plants and other means of adornment. The purpose of this is wholly practical. Even the expert in filtration who enters one of these rooms, swept and garnished with a meticulous nicety that few rooms of private residences exhibit, is bound to draw the inference that the more vital work of the plant is carefully and precisely performed. How much more impressive must be the effect on the citizen whose comprehension does not extend beneath the surface appearances! As a prominent filtration expert recently stated in discussion: "An attractive, neat and clean filter plant impresses the public fully as much as the process by which muddy water is converted into clean, sparkling filtered water, and creates an often unexpressed but nevertheless conscious confidence in the handling of their drinking water."

DANGERS IN DELAYING SIGNING OF CONTRACT.

Delay in signing the contract often results in a serious hardship to the contractor. It not only causes him much inconvenience but in these days of rapidly advancing material prices it is likely to make a decided difference to him in the cost of doing the work. This is particularly true of construction in which any considerable amount of structural steel is to be used.

An illustration of what may happen between the opening of bids and the signing of the contract is given by a recent happening in the East. Last December the Public Service Commission of the First District of New York City opened proposal for the building of a section of the dual system of rapid transit. Three weeks ago, after five months of negotiations, the commission signed the contract. At the time the contractor put in his bid steel could be purchased at $51.60 per ton and this figure was used in his estimate. When the contract was signed this material was selling in the market at around $83 per ton. This difference in price meant an increase of nearly $1,000,000 in the cost of the work.

In this particular case, however, the contractor had an option for the steel at the first mentioned figure so the delay may not cause him any great pecuniary loss on this item. It will undoubtedly cause him much inconvenience for a steel company selling its product $20 under the market price most likely will not display any special activity in making the deliveries. The New York case is an exceptional one; it is cited merely as an extreme example of the possibilities of the delay in closing the negotiations.

THE ARTICLE THAT APPEALS TO A LIMITED AUDIENCE.

The story is told of a worthy gentleman who, after a lifetime spent in study of the Greek dative, at death bequeathed continuation of his task as special reward to a favorite son. The illustration is caricature but all caricature has a foundation of truth. There are in every profession men who are specialists in minutae. The engineering profession is no exception. Perhaps the most evident of these specialists is the engineer who revels in abstruse computation. Another fruitful field in specialists in minutae is sanitary engineering. Also there are in engineering, groups of general practitioners whose work becomes highly specialized because they practice in localities where conditions are unique and complex. Every engineering journal has among its readers an audience generally small but exceedingly alert of these specialists. Catering to these audiences by means of articles of scant interest to the majority of his readers is an obligation upon the editor.

In this issue we publish an unusually complete article on treatment of the wastes produced in woolen goods manufacture. In this country the conditions which make this problem vital are confined to a very limited area. Within this area, however, the problem is of intense interest to the engineer commissioned with tasks of preventing contamination of streams, of water purification, of sewage treatment and of general public sanitation. It is not beyond the truth, indeed, to assert that to these engineers knowledge of the solution of this particular problem is vital. The interest of this select audience in the article which we publish is assured. Here we, therefore, wish to urge reasons why it should interest the general engineering reader.

The practice of the engineer is not limited by geographical boundaries. This is particularly true of those engineers who have matured into the ranks of consulting and advising engineers. Any one of these may at any time have a call for his services in a wool manufacturing center half a continent away from his usual and radically different field of practice. This which is true for the consulting expert is true also in varying lesser degrees for the ordinary practitioner. But there is a reason of broader application than this commercial reason why the general practitioner should read articles directed to the specialist outside of the field of general practice. The broad professional fitness of the reader is improved thereby. His mental horizon is extended. His appreciation of the universality of the services of his profession is increased.

AN $85,000,000 NATIONAL ROAD APPROPRIATION ASSURED.

After more than a decade of vigorous agitation in its favor a federal road building appropriation is about to be secured, for both the House and the Senate have passed bills that are in substantial agreement and the President has indicated his approval.

The bill that will soon become a law provides federal appropriations of the following sums for each of the years indicated:

1917	$ 5,000,000
1918	10,000,000
1919	15,000,000
1920	20,000,000
1921	25,000,000

In addition $10,000,000 is to be expended during the same period on roads and trails in the national forests. This makes a grand total of $85,000,000 to be expended during the next five years.

The appropriations are to be allocated to the different states as follows: One-third in proportion to area, one-third in proportion to population, and one-third in proportion to the mileage of rural delivery and star routes.

The states must themselves appropriate amounts fully equal to the federal funds thus provided, so that if every state avails itself of its opportunity a total of $150,000,000 will be spent in addition to $10,000,000 for national forest routes. The states must maintain the roads.

Road building is to be done under the direct supervision of the State Highway Department of each state, but plans, specifications, etc., must be approved by the Secretary of Agriculture.

The "Good Roads" magazine severely criticises this bill—as, indeed, it has criticised every federal appropriation—and it takes the irrational ground that the Department of Agriculture is not competent to play the part assigned to it. We quote:

> Another feature of the bill, which is open to objection, is the power it gives to the Department of Agriculture. This division of the government now can not be regarded as competent for this work, nor is it likely to be made competent under the provisions of the bill. The measure vests in the Secretary of Agriculture the power to approve the selections by local authorities of the road to be improved; to approve plans, specifications, and estimates for work to be done; to withhold money apportioned to any project, unless the roads for which it is to pay have been properly maintained, and to "make rules and regulations for carrying out the provisions" of the act. It is reasonable, of course, that if federal funds are to be used, the federal government should have some measure of control over the work done with those funds. It is not, however, advisable to place such control under a department or bureau which is not properly organized to exercise it. The bill should have made some provision for a federal organization of competent, experienced men, placed well above the influence of partisan politics.

We fear we see in this criticism a certain amount of personal spite. There are two national highway associations, for one of which "Good Roads" is the "house organ." The other organization has been independent of affiliation with any publication and it has espoused federal road appropriations—a policy that "Good Roads" has opposed. Quite naturally, we suppose, "Good Roads" has become progressively bitter toward the other national road association and its successful propaganda. The time will come, however, when "Good Roads" will regret not only its bitterness in this matter of federal aid in road work, but its effort to be the only mouthpiece of road associations.

Highway construction is too great an engineering field to be circumscribed by any periodical. Nor can policies of highway construction be dictated by any group of men. The sun has set on the day when, to kill a federal road bill, all that sufficed was to yoke its name to the words "pork barrel." Still less will it suffice to attempt to belittle the Office of Public Roads which has, for so many years, performed such efficient engineering work as a branch of the Department of Agriculture.

Federal aid in road building has come at last and it has come to stay. There are interstate roads even as there are interstate railways. It was inevitable that the federal government should join in furnishing capital for highways that are more than local in their utility.

THE RACE BETWEEN STEAM AND WATER POWER.

A 30,000 kw. (or 40,000 h.p.) steam turbine, with a maximum thermal efficiency of almost 25 per cent, is now furnishing electric current for the Interborough Rapid Transit Co. in New York City. Its normal daily thermal efficiency is 17 per cent, and it requires only 1.1 lb. of coal per h.p. hr., or 1.5 lb. per kw. hr. Sixteen years ago the Interborough power plant required 2.5 lb. of coal per kw. hr., so that a 40 per cent reduction in coal consumption has been effected for equal energy output.

The 30,000 kw. turbo-generator and its condensers cost $9 per kw. as against $40 per kw. that was paid 16 years ago for reciprocating engines, condensers and generators in units of 5,000 kw. Thus an enormous reduction in fixed charges as well as in fuel consumption has been effected. When it was announced a few years ago that a large turbo-generator plant could produce electricity at a cost of 0.5 ct. per kw. hr. when operating at about 50 per cent load factor, there were many engineers who doubted the accuracy of the estimate. Had all fixed charges been included—interest, depreciation and taxes? Had repairs reached a normal average? Had provision been made for the necessary standby units? Perhaps at that time some of these elements of cost were underestimated or entirely forgotten, but the fact is patent that now half-cent electricity, at 50 per cent load factor, can be generated on a large scale wherever coal costs not more than $3 a ton. Every dollar reduction in price of coal cuts down the cost about 0.07 ct. per kw. hr. where large turbo-generators are used.

We conclude, therefore, that with $2 coal, with generators built in very large units, and where land for power stations is relatively cheap, it is already possible to generate current at a cost of less than 0.4 ct. per kw. hr. when the load factor is 50 per cent or more. To this cost must be added the cost of transmitting and distributing the current, and the losses of energy incident thereto. But here it is that a steam plant normally has a marked advantage over a hydroelectric plant, for hydro plants are usually located at comparatively great distances from the points of distribution of the current. A hydro plant capable of generating and transmitting electricity to a distributing center at a cost not exceeding half a cent per kilowatt hour (at 50 per cent l. f.), was, until quite recently, regarded as a gold mine. Except where coal costs more than $3 a ton, or where relatively small amounts of current are required, it now is apparent that "a half cent hydro proposition" is no longer a gold mine.

It should not be forgotten, however, that the price of fuel has risen rapidly for several years and may rise even more rapidly in the next decade, whereas the price of large machinery has decreased. These conditions, coupled with improvements in the economic transmission of electric current, will doubtless result in further great development of water power, in spite of the steadily increasing thermal efficiency of engines.

The load factors of hydro plants can and will be made to approach 100 per cent as a result of the increasing rise of electricity in the manufacture of chemical products. Since the unit cost of current generated by water power varies almost inversely with the load factor, it follows that hydroelectric plants are destined to show greatly reduced costs per kilowatt hour.

We have, then, a race between steam and water power toward the goal of minimum unit costs. The betting odds seem to favor water power, in spite of the recent spurt that steam has shown.

EDITORIAL PARAGRAPHS.

That more railways have not been electrified is attributed by Henry L. Doherty to the antagonistic attitude of state and federal government toward railways. Mr. Doherty, a great electric engineer and public utility promoter and manager, is well qualified to express an opinion on this subject. He has raised millions of dollars for utility construction, and he has noted the disinclination of the public to invest where "fair returns" on the investment are limited by public service commissioners to 6 or 8 per cent. Let us have more published opinions from men of his character and experience.

For the most part the men who are public service commissioners are men who have never raised a dollar with which to build a public utility plant. Many of them have never financed anything save their own household expenses. They, therefore, are hardly to blame for talking of 6 per cent as an adequate return on a utility investment. The blame rests with those who have devised a system of selecting such officials under which neither engineering nor financial experience is a prerequisite.

A locomotive burning pulverized coal is to be exhibited at the Master Car Builders' convention at Atlantic City, June 17 and 20. If gasoline keeps to its present price, may we not soon see powdered carbon taking the place of gasoline in motor cars?

Remelting iron in vacuo has been found to improve its electro-magnetic qualities. Occluded gases in the iron are supposed to be liberated by vacuum fusion, making the iron more nearly pure. It will be worth testing such iron to see whether it is not less subject to rusting than iron not thus treated.

Coincident with its 50th anniversary, the Massachusetts Institute of Technology has just dedicated a new $7,000,000 group of buildings having 730,000 sq. ft. of floor area. The new buildings, which face the Charles River Basin, form an imposing classic group.

The year 1900 is only 15 years gone, yet in 1900 a committee of a well-known engineering association had for its subject: "Is Concrete a Suitable Material for Bridge Piers, Abutments and Railway Culverts and Arches?" Today the need of an alienist would be considered were this question asked. In 1900 it was not an unnatural query.

Two-course construction of concrete walks, floors, platforms, etc., is almost universal. Why? The top course is expensive. Does it serve in the majority of cases any desirable purpose which cannot be equally well served by proper one-course construction?

"How a contractor can advertise and get results" is discussed somewhat vaguely by a contemporary. One can think of several ways, but there is one way always open and in which publicity costs next to nothing at any time and sometimes will bring pay. This way is to describe and illustrate for the engineering journals interesting construction methods, devices, machines, used in engineering work. There is hardly one live contractor who cannot secure at least one advertisement of this kind for every job he completes.

Reversing the process of "carrying coals to Newcastle," the Union Carbide Co., of Niagara Falls, has been forced to erect a branch plant in Norway where it can get the additional "cheap waterpower" that it requires. How long will misguided sentiment prevent the fuller use of Niagara's power?

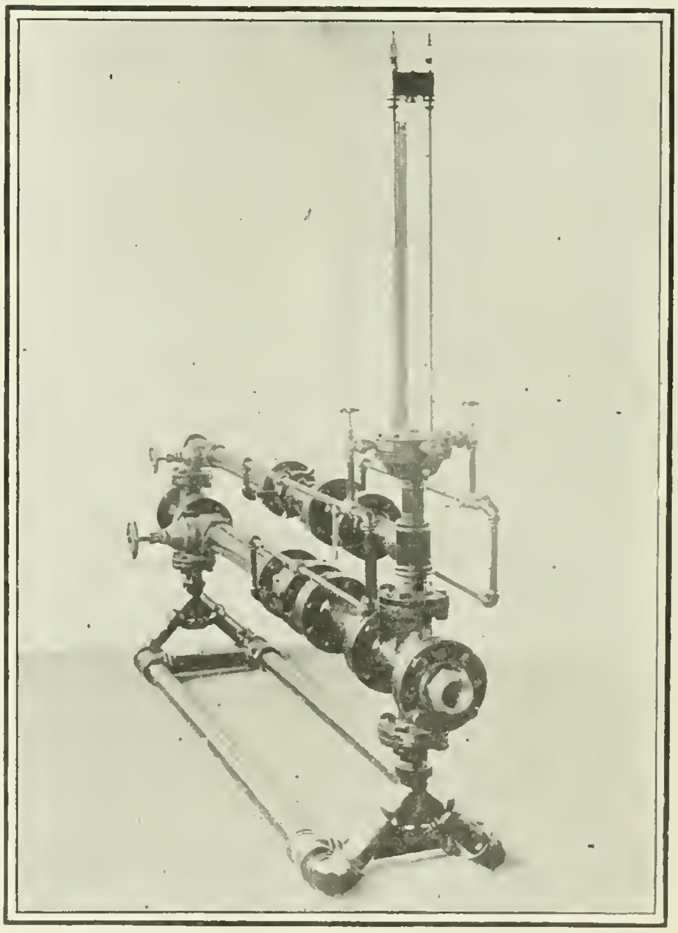
The officials of a street railway company in Boston are confronted with an unusual operating problem. Women's dress, which since the time of Eve has made trouble for the fairer sex, is the direct cause. When short skirts and hobbles came into fashion the State Public Service Commission ordered the street railways to lower their steps so that tight skirt wearers could get on without attracting a crowd. The company proceeded to fix up its cars to meet the requirements. After some 200 cars had been modified one of them was started through the subway. It then was discovered that the steps were so low that they couldn't get by the edges of the station platform.

It has been truly said that when the armies withdraw from Europe's battlefields the real wealth there originally, the soil's fertility, the water, the minerals, will be there still ready for the hand of man to transmute into useful products. One form of natural wealth of which this statement is not true is timber. The destructive consumption of timber in all the warring countries has been enormous, and trees are not the growth of a year or two. There is recompense, however, in the fact that the land denuded of trees becomes available for agriculture.

Recently we noted in this column how an engineer had turned his engineering knowledge to profitable service in managing a great tract of farming land. Before us is a recent bulletin from the University of Wisconsin on dairy barn construction and in that task as described we find a little to our astonishment more call for engineering skill than in many tasks acknowledgedly in the field of engineering. A modern dairy barn involves problems of water supply, ventilation, drainage and concrete construction of more complex character than is possessed by many concrete engineering structures.

APPROXIMATE ORIGINAL METHODS AND SUBSEQUENT SPECIAL DEVICE FOR MEASURING WATER WASTE AT ST. JOHN'S, NEWFOUNDLAND.

The weir measurements that were made when the study was first taken up indicated that during that period of a week the average rate at which the water flowed to the city was 5.3 million imperial gallons per day, representing a per capita consumption of about 166 imperial gallons per day, based upon the population connected with the distribution system. The measurements indicated further that the maximum rate at which the water was drawn throughout the 24 hours during the week of test was 5.8 million and the minimum rate 4.7 million imperial gallons per day, the minimum being over 80 per cent of the maximum: This minimum flow did not represent a compensating flow to a reservoir or anything of that sort, but clearly indicated a large waste throughout the 24 hours. There are but few manufacturing or commercial establishments that consume any considerable quantities of water regularly at night and it is, therefore, probable that the waste is constantly going on day and night at a rate somewhat approaching the observed night rate of flow.



Venturi Waste Detector as Used at St. Johns, Newfoundland.

One of the points of most importance to the city, therefore, was the detection and elimination of this waste. The practice of wasting water through house fixtures in the wintertime to prevent freezing is common and is freely admitted on all sides, and unfortunately this practice is not confined to the houses of the poorer class. The effect of this winter waste is to lower the water pressures all over the city, sometimes to the point of disappearance in certain sections. Entirely apart from the winter waste, there is the continual waste mentioned above, which is roughly indicated by the night rate of flow. Much of this large amount of waste could be detected and eliminated if the problem were properly attacked. The most effective way of getting at this would be by the use of meters. This

---

*Extract from a paper by F. F. Longley in June Journal of the American Water Works Association.

was recommended and it is to be hoped that the city will adopt the recommendation.

From the magnitude of the waste, it appeared that something might be done rather rapidly to indicate where the loss mainly occurred, by means of a subsurface study of the distribution system. Therefore various parts of the distribution system were isolated and a rough measurement of the night flow into such districts made, assuming this night flow to represent approximately the leakage therein. Suitable equipment for convenient and accurate measurement was not at hand and it was therefore necessary to improvise a method with the material available. This was done at first by simply connecting a hydrant within the isolated district to one outside, through a fire hose of known length and diameter, and measuring the drop in pressure between the two hydrants, making proper corrections for differences in elevation. The quantity flowing was then roughly estimated from the friction loss through this hose. This obviously was a preliminary step only, but it resulted in showing in what districts to look for large waste, and a rough approximation of the quantity of leakage therein.

Later, a meter was inserted in the hose line. Careful observation of the meter gave indications of changes in the rate of flow and this method was used to follow up the first method. The isolated district was then reduced in size by successively closing all available gates, while the meter was under continual observation, and this resulted in a much closer localization of the waste.

From these rather rough methods it was made clear that from 75 to 80 per cent of the total night flow in the districts examined was on the house services and only 20 to 25 per cent on the mains. This, of course, was followed up as vigorously as possible by a house to house inspection and produced results which have encouraged the city to plan further and more thorough work along similar lines.

Owing to the fact that the available force has been busily engaged during the past year on construction work, the matter of waste reduction has not been followed up as actively as might have been wished, but it is to be followed up when conditions permit. An apparatus for use in connection with this work has been secured and a picture of it is shown herewith. It consists, as will readily be seen, of two small Venturi meter tubes, one 3 in. x $1\frac{1}{2}$ in., the other 2 in. x $\frac{5}{8}$ in., erected on the same stand and connected by suitable pressure pipes and valves to a manometer with two scales, one for each of the meter tubes. By means of this apparatus inserted in the hose line connecting two hydrants, one within and one outside of the isolated district, very small changes in rate of flow into the district may be observed, yielding information which will permit the elimination of even small amounts of waste on the various services. This equipment was tried out in St. John's two or three months ago and found to work with excellent satisfaction.

MUNICIPAL AND SANITARY ENGINEERING SERVICE.

By G. R. Bascom.

Most of the towns of Wisconsin having a population of 3,000 or more have made substantial beginnings in the line of municipal and sanitary improvements. There are, however, a great many of the smaller towns and villages which have, as yet, done little toward community improvements. This is due to various causes, chief among which is, perhaps, the lack of a leader among the people who could show how these things could be made paying investments for the small town.

If, then, it is true that the cities, villages, and communities quite generally need improvements which have a direct bearing on the health, economics, and general welfare of these places, is it not a matter of economy and efficiency to create some system by which this engineering promotion or this educating the people to their needs can be systematically and impartially carried on? There is little doubt that even the engineer in private practice will agree to this, providing the work is carried on impartially and providing the service given is limited in such a manner that the legitimate business of the engineer in private practice is not taken over by the new agency. Of this the writer has been reassured by a great many opinions which were solicited prior to beginning the work in Wisconsin and at every opportunity since. It is quite interesting here to note that in not a single case did the engineers consulted as to opinions on this service disapprove of the service if carried out on the plan which we had outlined. One or two pointed out the difficulty in drawing the line between promotion services and engineering services which would take away the legitimate business of the practicing engineer. However, the opinions have been generally favorable, and in almost every case we have met with hearty approval and offers of co-operation which have been an inspiration in our work.

The general scope of this engineering service is in the form of advice to communities and individuals. The service is intended to be limited to the field covered by the usual "preliminary survey" as furnished by experts in advising generally upon engineering subjects. Finished plans and specifications will not be submitted. If necessary the department will send a competent engineer to investigate and make a report on the problem at hand. These services are free except in cases when an engineer must make trips to study the conditions; in such cases the community is expected to reimburse the department for the traveling expenses of the engineer. To illustrate, if a village has some inclination to install a public water supply, and as a result of a special local meeting, calls upon the Extension Division for advice, the engineer is invited to visit the town. He makes a careful study of the conditions, and after gathering all the data needed, submits a carefully prepared outline for a proper system of water supply for the village in question. This report will contain only such sketches as are necessary to show the plan of the system as a whole, will state the essential features necessary to its proper design, and will also give an approximate estimate of the cost of the improvements. The plan may be further explained, if desired, in an address by the engineer to the taxpayers of the village. Here the work of the Extension Division ends. If the village officials decide to go ahead with the plan, a consulting engineer in private practice is employed by them to work out detailed plans and specifications and supervise the construction.

It can thus be seen that in this service we are advising, guiding, and inspiring rather than serving in an engineering capacity in its fullest sense. We believe that we are filling a real need, for the work has thus far clearly demonstrated the fact that Communities will take the impartial advice of the University Departments where the overtures made by individuals in the promotion of public improvements might be viewed with suspicion. In this work we are trying to advise against unnecessary expense as well as encourage new improvements; and since we neither sell material nor collect fees, our advice is appreciated by the average layman.

It is a well-known fact to those who have carefully considered the subject, that our cities and villages are paying much more than they should for public improvements. The causes are subtle and many, but all can be classified as due to ignorance on the part of the general public. In offering this Engineering Service, we can be and have been of great value in protecting the communities against an undue amount of piracy in awarding contracts for public improvements.

A considerable part of the service can be carried on by correspondence, for example—we write opinions on such subjects as: "comparative value of asphalt, pitch, and grout filler for brick paving joints," "comparative value of natural and refined oil asphalts," "methods of road oiling," "processes of water purification," etc.

The following summary shows the extent of the service during the time the writer has been in charge.

First Year: July, 1913-July, 1914.
11 communities served.
13 subjects treated.
4 trips made.

Second Year: July, 1914-July, 1915.
27 communities served.
42 subjects treated.
13 trips made.
Third Year: July, 1915-April, 1916.
36 communities served.
53 subjects treated.
11 trips made.

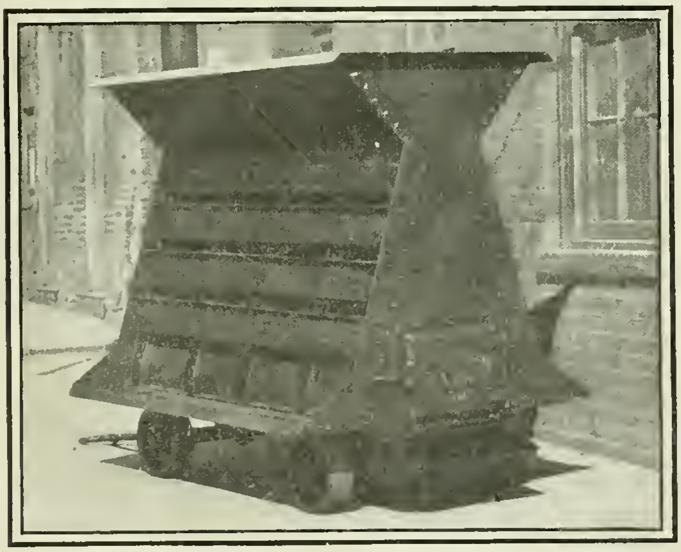
The subjects covered by this branch of the Extension Division service are those which fall under the general head of Municipal and Sanitary Engineering, such as: Water Supply; Sewerage and Sewage Disposal; Roads and Pavements; Refuse and Garbage Disposal; General Sanitation; Street Cleaning and Sprinkling; City Planning, and Building Laws and Plumbing Regulations.

We have done little to advertise the service because of the fact that the funds to carry on the work were limited, and yet where we saw the need of educating a town on the need of certain improvements, we have made use of the Community Institute and special lectures to stimulate general interest.

A HEATER AND DRIER FOR BROKEN STONE AND GRAVEL.

(Contributed.)

The illustration shows a heater for stone and gravel which has been successfully used in street paving and concrete construction. As shown the device consists of a multiple perforated sheet of heavy metal bent over rooflike to form the two heating sides. In cross-section it resembles an inverted letter V. At the ends of this multiple sheet are two solid end plates, in one of which is a fire door, and to which also fasten the multiple perforated flights that are arranged down the sides of the furnace to form the heating chambers and the hopper that is arranged above the point of the furnace.



Heater for Stone and Gravel.

The perforated flights are about 3 in. removed from the furnace sides at their bottoms, and about 5 in. removed at their tops, causing the gravel that passes under them to do so in a layer averaging about 4 in. in thickness. The hopper discharges on both sides of the furnace under the topmost perforated flight on either side, having two 5-in. openings separated by the point at the top of the furnace. A smoke stack is arranged at the top of the furnace for starting the fire; and grates, wheels, ash pans, hot gravel pans, etc., are arranged at the bottom in quite the usual way.

But one man is required to operate the machine. He tends the fire, shovels cold, wet gravel into the hopper and shovels hot, dry gravel away at the bottom into wheelbarrows to be taken to the men at work, and he does not work overtime. As he removes the hot, dry gravel banked at the base of the machine, the gravel from the hopper gravitates freely down over the multiple perforated furnace side and under the multiple perforated flights until it is again banked at the base. The machine shown illustrated has a capacity of about four tons of gravel per hour, or forty tons per ten-hour day.

Littleford Brothers, of Cincinnati, Ohio, who are manufacturers of melting kettles and other contractors, and industrial equipment, have secured from the inventor and patentee, Mr. Charles A. Mullen, of New York City, a license to manufacture and sell these heaters, and will henceforth handle them along with their general line.

ADOPTION OF FRENCH ROAD SYSTEM PROPOSED FOR NEW JERSEY HIGHWAYS.

The application to New Jersey conditions of certain features of the French road system, recommended by Mr. E. A. Stevens, Commissioner Department of Public Roads of New Jersey, in a report submitted to the special commission appointed by the Governor to consider highway legislation. Mr. Stevens believes that two features of the French system are applicable: First, the organization of the road force, and, second, the classification of roads.

Under the plan suggested streets, boulevards, park roads, etc., which from their very nature must receive different treatment from country roads, would be eliminated from the highway classification. The remaining roads would then be divided into at least three classes, as follows: (1) Roads of importance to the whole state; that is, trunk lines carrying a large amount of through traffic. These would be state highways. (2) Roads of secondary importance, main feeders to trunk line roads, or connecting points of secondary importance. These would be county roads. (3) Roads of local importance only.

The state highways would be selected by some state authority, preferably a board, and not the legislature. They would comprise about 10 per cent of the country road mileage and would carry some 65 per cent or 70 per cent of the traffic. County roads would be chosen by the county freeholders, subject to state approval. The mileage would be limited to about 20 per cent of the total country road mileage. The county roads would carry 15 per cent to 25 per cent of the traffic. The local roads would constitute about 70 per cent of the total, but would not carry more than 10 per cent to 20 per cent of the traffic.

To provide for the improvement and upkeep of the roads Mr. Stevens proposes a state road force with a chief engineer as its head. This force would be divided into two or more grades, the upper one being engineers, and the lower one inspectors, foremen, road overseers and patrolmen. These grades would include all the skilled men used. Admission would be by civil service examination and upper grades would be filled by promotion, after examination, wherever practicable. It is suggested that any public body applying for or receiving state aid in any way, must employ none but members of the State Road Force, excepting, of course, for ordinary labor. The men for this skilled work would be detailed by the Chief Engineer or some of his subordinates and would be subject to recall by him.

COST OF DRIVING A $7\frac{1}{2}$x8-FT. HEADING IN HARD ROCK.[*]

The heading, $7\frac{1}{2}$x8 ft. in the clear, was driven 2,916 ft. at an average rate of 8 ft. per day. The best weekly record was 67 ft. and the best monthly 271 ft. Two 8-hour shifts per day were employed, consisting of four machinemen and three shovelers. After the 1,000-ft. mark was passed, four shovelers were employed. Compressed air at 100-lb. pressure was delivered into the tunnel through a 4-in. pipe. Two $3\frac{1}{4}$-in. Ingersoll-Rand E44 drills, mounted on a 7-ft. single screw bar, were used. Miners and shovelers started work together. The bar was set up above the rock pile, and from 10 to 12 holes were drilled from this position. By this time the rock was out, the bar was lowered, and three lifters were drilled. The first 1,600 ft. of the tunnel is in greenstone, while the remainder is in argillites, quartz and porphyry.

---

[*] Abstract in Engineering and Mining Journal of a paper by W. J. Elmendorf, Trans. Can. Min. Inst., 1916.

With but two exceptions during the entire work, a round was drilled in every shift. Five-foot rounds were drilled, but seldom "bottomed." Three 20-cu. ft. cars were used, and tramming was done by the shovelers. The track of 20-lb. rails, 18-in. gage and ½ per cent grade, was laid on the left-hand side of the tunnel. One switch, about half way in, was used; the empty incoming car was taken off the track near the face to allow the loaded one to pass. At a point 730 ft. from the portal an 80-ft. adit was run, opening into a canon. This not only made an excellent dumping place, but shortened the tramming distance by 750 ft. The shovelers laid and leveled the track. The floor from within 3 ft. of the face to 40 ft. back was covered with steel plates before blasting. A drain 12 in. deep was made on the right side of the tunnel, the lifter being drilled low for this purpose.

Ventilation was provided by two Schutte & Korting blowers. The ventilating line consisted of 10-in. diameter 24-gage galvanized pipe. The pipe was made in 10-ft. lengths with riveted joints, painted with tar and wrapped with muslin. The compressor was run two hours after blasting to clear the tunnel.

TIME AND COST OF OPERATIONS.

Average Time of Operations.	Hr.	Min.
Picking down and setting up	1	00
Drilling from upper set-up	4	30
Shoveling back and lowering bar	0	30
Drilling from lower set-up	1	15
Tearing down	0	10
Blowing out holes	0	5
Loading	0	15
Total	7	45

Detailed Summary of Costs.	Cost per foot.
Labor:	
Machine men	$ 3.953
Shovelers	3.673
Timbering	.258
Drainage	.042
Ventilation	.077
Ties and wedges	.135
Compressed-air line	.072
Compressor men	1.166
Blacksmith and helper	1.216
Superintendent	.876
Total	$11.468
Supplies:	
Powder	$2.562
Fuse	.134
Caps	.032
Candles	.145
Blacksmith coal	.125
Machine drills and parts	.503
Drill steel	.118
Timbers	.052
Repairs on compressor	.027
Oils	.031
Miscellaneous	.073
Total	$3.802
Equipment:	Total cost.
Muck sheets	$ 110.00
Steel rails	1,290.00
Ventilators	225.00
Ventilating pipe	960.00
Compressor air line	1,070.00
Cars	400.00
Total	$4,055.00
Length of tunnel, ft.	2,916
Total cost	$48,584.01
Cost per foot	$16.661

The prices of some of the more important supplies at the tunnel were as follows: Dynamite, 40 per cent, $0.134 per pound; 60 per cent, $0.159 per pound (powder was used in about the proportion of 30 per cent of the former to 70 per cent of the latter); steel rails (20-lb.), $72.24 per long ton; blacksmith coal, $27 per ton.

The scale of wages was as follows: Machinemen and shovelers, $4 per day; blacksmiths and compressor men, $5.

New School of Chemical Engineering Practice.—The Massachusetts Institute of Technology, Boston, Mass., will establish a new department of Chemical Engineering Practice. The school will include regular courses with a resident professor at five or six industrial plants, each equipped with a research laboratory. These stations are to be located at Somerville, Mass.; Bangor, Me.; Niagara Falls, N. Y.; Allentown, Pa., and Chicago. The course leading to a Master's degree after five years' study, includes 3½ years at the Institute, 9 months at the several industrial plants and the last 9 months in the Institute laboratories.

CONSTRUCTION FEATURES OF AN ASPHALTIC MACADAM ROAD IN MASSACHUSETTS.

During the season of 1915 a section of state highway in the town of South Hadley, Mass., was surfaced with an asphalt-broken stone mixture. The improvement involved a number of interesting features, including the use of a seal coat to obtain a denser pavement than was possible with the aggregate available. The following description of the constructural methods is taken from a paper presented at the March conference of the Massachusetts Highway Commission by Mr. E. H. Townsend of the engineering staff of the Commission. We also are indebted to Mr. Townsend for the photographs illustrating the article.

The subsoil was chiefly clay and for several years previous to resurfacing it was noticed that the frost action in this sub-soil produced heaving of the surface with consequent disintegration of it. Therefore the surfacing was laid on a foundation of 6 in. of gravel and 8 in. of large stone fragments with about 2 in. of broken stone screened from the old macadam. Upon this was placed the 2-in. surface consisting of a mixture of broken stone and asphalt.

The stone used in the mixture was a hard local trap. All of the crusher product passing a 1¼-in. screen was used in the aggregate. The matrix material was a cut-back petroleum product with the trade name of Texaco No. 54 Paving Cement. This is a heavy bituminous material of specific gravity about 1.03 and a penetration of about 75.

The bitumen was to be thoroughly incorporated with the stone by means of a mixing machine. The apparatus used by the contractor on this construction was a Cummer Asphalt Plant.

The asphalt and aggregate were measured to the proper proportion by weighing and each was introduced directly to the mixer from the scales. The asphalt was heated to about 350° F, which temperature seemed the lowest at which asphalt of such consistency could be readily mixed with stone. The stone was heated to about 225° F. This temperature is sufficiently above the evaporation point of water to insure the rapid vaporization of the moisture contained in the mass of aggregate.

As soon as the asphalt was thoroughly incorporated with the stone a slide was opened in the bottom of the mixer allowing the material to drop into a waiting cart beneath. About ten batches, each containing 4 cu. ft. of stone, were necessary for one load. As the average rate of mixing was one batch per minute, 10 minutes were necessary in filling the cart. As soon as the cart was filled the mixture was teamed to the road and dumped on a steel dumping board whence it was placed on the road by shovels and brought to the proper thickness and cross-section by means of rakes. The mixture was best handled when it was placed on the road at a temperature of not less than 200° F. At this temperature it was sufficiently plastic to be readily spread and rolled. A lowering of this temperature was followed by a marked stiffening or setting up in the mass with a consequent reduction in ease of handling. The rolling was kept up as close as possible to the spreading of the mixture, a space of 6 ft. to 8 ft. usually intervening between the two operations.

The proportion of the mixture as specified was 16 gal. asphalt measured at air temperature to 1 cu. yd. of loose aggregate. This proportion was used at the start but it was obvious at once that more asphalt was needed to coat thoroughly the particles of the aggregate. Eighteen gallons per cubic yard was then tried. This proportion coated the aggregate thoroughly but it was found after placing and rolling the mixture that the surface was porous to a depth of about 1 in. In other words after thorough compression, the pavement lacked density due apparently to a preponderance of large particles in the aggregate. It became apparent at this time that one of the chief problems with the mixture would be the attainment of a dense surface which would seal over during the process of rolling.

Therefore, in the solution of this problem two things were necessary, the introduction of more fine particles into the aggregate and consequently the use of more asphalt, as subsequent experiments showed that a finer aggregate, having more particle surface required more asphalt to coat this surface. Some adjustments were made in the crusher, the jaws were set closer and the method of screening was changed. The result was that the output contained a larger percentage of fine particles. This required the use of more asphalt per cubic yard of stone and the amount was increased from 18 to 20 gal. and then to 21 gal. The resulting pavement was denser than the first experiments and showed a much greater tendency to seal over under rolling. The surface, however, was still porous, the top particles protruding from the denser part of the pavement, from ¼ in. to ½ in. There apparently was no other way of obtaining a denser pavement with the aggregate available. Further adjustments of the crusher resulted in no appreciable increase in the amount of small particles in the aggregate and the introduction of more asphalt into the mixture was found to be impossible. The aggregate was supplied with as much bitumen as it would carry, for additional asphalt ran out of the mass and was lost in transit.

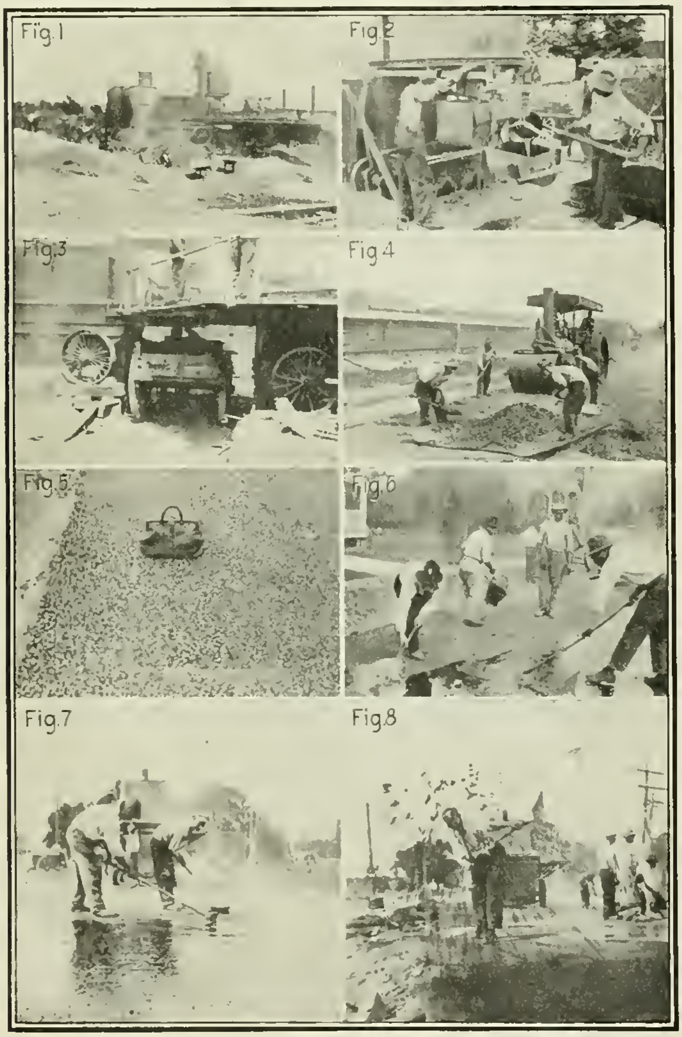


Fig. 1—Mixing Plant and Stone Piles. Fig. 2—Weighing and Carrying Bitumen From Kettles to Mixer. Fig. 3—Cart Being Loaded at Mixer. Fig. 4—Spreading and Rolling Mixture. Fig. 5—Appearance of Surface Before Application of Flush Coat. Fig. 6—Applying Flush Coat. Fig. 7—Seal Coat. Fig. 8—Spreading Grits.

The specifications made no allowance for the introduction of a finer material by adding to the aggregate a sand of fine crusher product. We were restricted to the use of a crusher run and after experimenting with the product until the aggregate contained the least amount of voids, as nearly as could be determined without actual analysis, we still had a pavement which was porous on the top and doubtless would soon pick up under the heavy usage of the traffic. Furthermore the entire pavement was opened to penetration by moisture and the resulting disintegration caused by water standing on an asphalt surface.

The use of a flush coat to seal over the surface and obtain a water tight pavement was determined upon, and the same kind of asphalt was used as in the mixture. The asphalt was applied to the surface from pouring pots and wiped down to a uniform thickness with squeegees, care being taken to pour and to carry the strokes of the squeegee lengthwise of the road.

As little asphalt was used as would insure sealing over the surface, this amount being about ⅔ gal. per square yard. It was found that the asphalt was most easily wiped down to a uniform thickness when it was applied at not less than a temperature of 375° F. Immediately after application it was covered with a clean ¼-in. grit, spread at the rate of about 20 lb. per square yard.

The applying of the flush coat was performed as close to the spreading of the mixture as possible. By so doing the advantage of placing the flush coat on a clean, warm surface was gained. In gaining this advantage the use of a pressure distributor was precluded. It should be kept in mind that no penetration of the stone was required as all particles were already coated. The mere sealing over of the surface was the end in view and the method of application adopted was apparently effective in attaining this end.

At the time of applying the flush coat was scarcely 1/16-in. in thickness. The action of the traffic gradually pressed the covering of grit into the flush coat until it became a part of the wearing surface. The result was that the flush coat by the addition of this grit increased in thickness to ¼ in. to ⅜ in.

The resulting surface is similar in appearance to some patented pavements of similar construction. It has a smooth, rubbery appearance peculiar to asphalt surfaces, which appearance is probably pronounced in the case of surfaces constructed with a mixture and finished with a flush coat.

During the warmer months of the year the surface was sufficiently receptive to give a good footing for horses. But when the weather is colder the pavement became hard and slippery, not so much so as a sheet asphalt or wood block pavement, but enough to give insecure footing for horses hauling heavy loads on the grades. This condition is not unusual in pavements of this type and can probably be remedied by the application of a course grit during the warm period when the pavement is sufficiently soft to receive this grit under the pressure of the traffic.

The pavement has only been completed for a period of about 7 months and up to date gives every indication of being a most durable surface. The proof of this road is in its quality to stand up under the test of time and heavy traffic and after 7 months more elapse and the road has passed through one complete cycle of its existence, some dependable prophecy may be made of its future.

Southwestern Concrete Association.—Permanent organization of the Southwestern Concrete Association was completed at a meeting held at Kansas City, Mo., on May 26. At a well attended meeting of those who have been instrumental in developing the sentiment along this line, the constitution and by-laws were adopted and the officers for the year elected. The association is formed "for the purpose of discussing the various questions arising from time to time of interest in the uses of concrete, and to exchange views as to the best methods to extend and develop its use, and to do all things incidental and conducive to the attainment of the above objects." The president of the association is G. B. Appo, publisher of Portland Cement, Kansas City, Mo.; first vice president, Martin Carroll, general contractor. Kansas City, Mo.; second vice president, W. F. Fague, with Sunflower Portland Cement Co., Kansas City, Mo.; secretary, H. H. Peters, manager Western Contractor, Kansas City, Mo.; treasurer, Chas. A. Stevenson, Kansas City manager, Lansing Company.

PURIFICATION OF THE WASTES FROM THE FINISHING OF WOOLEN GOODS.

Contributed by H. R. Crohurst, Sanitary Engineer, U. S. Public Health Service, and A. D. Weston, Sanitary Engineer, State Department of Health, Massachusetts.

After the preliminary scouring of the raw wool to produce a clean fiber, free from the many impurities which it always contains, the fiber is spun into yarn or woven into cloth. After leaving the spinning or weaving room it is subjected to the finishing process. This consists of a second scouring, a fulling or milling process, bleaching in the case of white flannel and worsted yarn, and the dyeing of other goods. Before picking and during the spinning and weaving of the wool fiber, oil in varying quantities, according to the nature of the fiber used and the character of the finished product, is added to assist in the operations. This oil, together with any dirt which may have been taken up during these processes, must be expelled before the goods can be properly finished. Wilson and Calvert in Trade Waste Waters estimate that oil varying anywhere from 2 to 3 per cent of the weight of the goods for worsted yarns, up to 25 to 30 per cent for shoddy and other low class goods, may be added in the manufacture. The oil is applied to the goods as an emulsion. Two formulae for making this emulsion and the quantity to be used are as follows:

No. 1—For every 100 lb. of wool use: 6 qt. of olive oil, 10 qt. of hot water, small amount of ammonia.

No. 2—For every 100 lb. of wool use: 8 qt. of lard oil, 10 qt. of hot water, 2 oz. of borax.

Although the machines used in the cleaning of the various classes of goods may differ to some extent in detail, the general principle in cleaning is the same for all. The goods leaving the weaving room may first be scoured or washed and then fulled, in which case a second washing is necessary before the dyeing can take place, or they may be first fulled and then scoured, in which process there is one less washing. With other classes of goods which require no fulling there is simply a scour and rinse. A brief discussion of these processes follows:

Scouring.—The scouring of piece goods is usually carried out in a washing machine, or "dolly washer." This consists of a vat which contains the washing solution and is provided with suitable outlets in the bottom for the discharge of dirty water and solutions and proper inlets for wash waters. The goods are usually run through the machines in the form of an endless chain, several of these chains being scoured at once. The inlets for wash water are so arranged that they come opposite each chain and the water entering strikes against the goods in the machine. Guide rolls and squeeze rolls arranged to bring the goods into and out of the solutions alternately are provided so that there is a constant saturation of the goods with the cleaning liquor and then a pressing process in the squeeze rolls which expels it with the dirt and oil. In this way the impurities in the goods are softened and loosened and finally are washed out with large quantities of clean hot and finally cold water.

In the scouring of yarns the hanks may be either suspended in a vat of the scouring liquor and moved back and forth by hand and then washed in clean water or they may be made into an endless chain and scoured in a manner similar to the scouring of piece goods. As in the scouring of the raw fiber, the strength of the scouring solutions and the quantities of dirt and oil washed from the yarn or cloth varies with the weight and the character of the material being scoured.

In yarn scouring it has been estimated that about 6 to 7 lb. of soap per 100 lb. of yarn were used. For light woolen goods 6 to 10 lb. of soda ash and 2 to 3 lb. of soap dissolved in 25 to 30 gal. of water for every 100 lb. of goods are used, followed by a second wash consisting of a solution of 4 lb. of soap in 20 gal. of water. For heavy woolen goods or shoddy the solution is much stronger, sometimes consisting of as much as 7 lb. of soda ash in 30 to 40 gal. of water per 100 lb. of material.

The following formulas are given as scouring solutions used for most woolen goods. The following quantities of reagents will be found in every 16 to 20 gal. of the liquor:

1 lb. of good soap or
1½ lb. cottonseed oil soap.
3 lb. of alkali.
½ lb. sal-ammoniac.

For worsteds every 16 to 20 gal. of scouring liquor will contain:

2 lb. olive oil soap.
3½ lb. of alkali or 6 lb. of sal-soda.
½ lb. sal-ammoniac.

Fulling.—From the scouring machines the goods ge through the fulling or milling operation. The theory of fulling is to give the fibers a felting action causing them to overlap and form a firm surface on the cloth. Pressure, moisture and heat are necessary in this operation. The solutions used consist of soap to which carbonate of soda or Fuller's earth may be added. The goods pass through the solution then through heavy rolls with a back pressure on the cloth in a machine somewhat similar to that used in scouring. During fulling there is considerable shrinking of the cloth, which makes it more even and uniform in its structure. As an example of the solution used in fulling the following formulas are taken from the Cyclopedia of Textile Works, Vol. 7:

Caustic Soap: Dissolve 8 lb. of caustic soda and 4 lb. of caustic potash in 20 gal. of water. 70 lb. of tallow are melted and when the above lye has cooled to about 80° F. it is poured into the tallow. At the end of a week a hard soap will result.

Potash Soap: 50 lb. of pure caustic potash are added to 5 gal. of water. When cool pour into a mixture of 20 gal. of cottonseed oil and 20 lb. of clear melted tallow. The result will be 300 lb. of highly concentrated neutral soap.

When the goods are fulled before scouring the fulling solution must have strength enough to start the grease and body enough to last through fulling. The solution is made up as follows:

100 lb. of potash soap.
5 gal. of water.
5 lb. of pearl ash.
10 oz. of palm oil soap.

After passing through the fulling process the goods pass to a washer containing warm water. They pass in an endless chain into the water and out through squeeze rolls, the operation continuing until the soap, oil and impurities are started. The warm water containing these foreign substances is then drained away and fresh, clear, warm water sprayed onto the goods until free from soap, after which they are washed in cold water for from 45 to 50 minutes. The soap used in the washing after fulling is that added for the process of fulling. Fuller's earth, used after the goods are washed, removes any traces of soap and leaves the goods soft. Earth free from impurities is used. About 2 pails full of earth are added to 50 gal. of water to form a solution of which about 2 pails full are used to each piece of goods. After the rinsing off of the soap in the washers the goods are run in the solution for 15 minutes and then rinsed. After the scouring process the goods are ready for bleaching in the case of white flannels and white worsted yarns, and for dyeing in the other classes of goods.

Bleaching.—Flannels and white worsted yarns are bleached by having them thoroughly moist and hanging them in an atmosphere of sulphur dioxide for from 8 to 24 hours, depending on the class of goods, after which they are thoroughly washed. This is known as the "gas" or "dry" method of bleaching. The "wet" process consists of steeping the goods in a dilute solution of sodium bisulphide for a number of hours and then passing the goods through a dilute solution of sulphuric acid. The wash waters from the washing of bleached goods is liable to contain acid and constitutes a waste. Sodium peroxide and hydrogen peroxide are also being used for the bleaching of woolen goods. Sodium peroxide with sulphuric acid in dilute solutions yields sodium sulphate and hydrogen peroxide which in the presence of organic matter is broken down into water and nascent oxygen which attacks and destroys the coloring matter in the fiber. When hydrogen peroxide is used a ½ to 1 per cent solution is made up and silicate of soda added to make the bath alkaline and the goods treated in this.

Dyeing.—Dyeing usually consists of treating the goods directly in the hot dye bath and then washing, or first treating the goods with a suitable mordant to fix the dye when run into the dye vat and then washed or treated with an oil or other bath to clear and fix the color.

The following notes, taken from Perkin and Kipping, Organic Chemistry, Part 2, will give some idea of dyes, their application and some of the processes and solutions used in the dye house:

Dyes and Their Application.—Although most organic compounds are colorless, some, especially certain classes of the aromatic series, are intensely colored substances, among which representatives of almost every shade occur. Most of the principal dyes used at the present day are in fact aromatic compounds, the primary source of which is coal-tar, hence, the well-known expression, "coal tar colors."

That a dye must be a colored substance is, of course, obvious, but a colored substance is not necessarily a dye in the ordinary sense of the word, unless it is also capable of fixing itself or being fixed in the fabric to be dyed in such a manner that the color is not removed by rubbing or by washing with water.

If a piece of silk or wool be dipped into a solution of picric acid it is dyed yellow and the color is not removed by washing, but is fixed in the fiber. If, however, a piece of calico or other cotton material is treated in the same way the picric acid does not fix itself, but may be removed by washing with water. A substance may therefore be a dye for certain materials, but not for others. The animal fibers, silk and wool, fix picric acid and are dyed by it, but the vegetable fiber, cotton, does not—a behavior which is repeatedly met with in the case of coloring matters.

Now, since picric acid is soluble in water, it must have undergone some change when brought into contact with the silk or wool, otherwise it would be dissolved out of the fabric on washing with water. Materials such as wool, cotton, silk, etc., consist of minute fibers which may roughly be described as long cylindrical or flattened tubes (except in the case of silk, the fibers of which are solid), the walls of which, like parchment paper and animal membrane, allow the passage of water and dissolved crystalloids by diffusion, but not that of colloid substances, or, of course, matter in suspension. If, therefore, the picric acid were present in the fiber as picric acid it would be rapidly washed out and pass into the water by diffusion. As this is not the case, it must be assumed that it has actually combined with some substance in the silk or wool and has been converted into a yellow compound which is either insoluble or a colloid.

Granting that the fixing of a dye within the fiber is the result of its conversion into some insoluble compound, it seems reasonable to suppose that even if a coloring matter be incapable of fixing itself in the fiber of the material it might still be employed as a dye, provided that after it had passed through the walls of the fiber it could be there converted into some insoluble compound by other means. This principle is employed in the case of many dyes and the substances used to fix them in the material are termed mordants.

Dyes may therefore be roughly divided into two classes with respect to their behavior with a given fabric. (a) Those which fix themselves on the fabric, and, (b) those which do so only with the aid of a mordant.

Mordants are substances which usually after first undergoing some preliminary change combine with dyes forming insoluble colored compounds, the color of the dyed fabric in such cases depends, of course, on that of the compound thus produced and not on that of the dye itself, so that by using different mordants or colors different shades or colors are often obtained. As an example of the dyes of the second class alizarine may be taken, as it illustrates very clearly the use of mordants.

If a piece of calico be dipped into an aqueous solution of alizarin it is colored yellow, but the color is not fixed and is easily expelled by washing with soap and water. If, however, the piece of calico has previously been mordanted by a suitable aluminum salt, in a manner described below, and be treated in the same way, it is dyed a fast red, the alizarin having combined with the aluminum salt in the fiber to form a red insoluble substance. If again the calico has been mordanted with a ferric salt instead it would have been dyed a fast dark purple.

Substances very frequently employed as mordants are certain iron salts, salts of aluminum, chromium and tin, more especially those such as acetates, thiocyanites, and alums which undergo decomposition on treatment with water or steam, yielding either an insoluble metallic hydroxide or an insoluble basic salt.

The process of mordanting usually involves two operations; first, the fabric is passed through or soaked in the solution of the mordant in order that its fibers may become impregnated with the metallic salt; second, the fabric is treated in such a way that the salt is decomposed within the fibers and there converted into some insoluble compound.

The second operation of fixing the mordant so that it will not be washed out when the fabric is brought into the dye vat is accomplished in many ways. One of the simplest is to pass the mordanted material through a solution of some weak alkali (ammonia, sodium carbonate or lime) or some salt, such as sodium phosphate or arsenate, which interacts with the metallic salt in the fiber, forming an insoluble metallic hydroxide, phosphate, arsenate, etc. Another method applicable, more especially in the case of mordants, which are salts of volatile acids, consists of exposing the fabric to the action of steam at a suitable temperature. Under these conditions the metallic salt dissociates, the acid volatilizes with the steam and an insoluble hydroxide or basic salt remains in the fiber.

In the case of silk or woolen goods the operations of mordanting and fixing the mordant may often be carried out simultaneously by merely soaking the materials in a boiling dilute solution of the mordant. Under these conditions the metallic salt is partly dissociated and deposited in the fiber in an insoluble form. Silk may sometimes be simply soaked in a cold concentrated solution of the mordant and then washed with water to cause the dissociation of the metallic salt.

In cases where only parts of the fabric are to be dyed, as in calico printing, a solution of a suitable mordant may be mixed with the dye and with some thickening substance, such as starch, dextrine or gum, and printed onto the fabric in the required manner, the thickening preventing the mordant from spreading to the other parts. The material is then submitted to a steaming process, when the metallic hydroxide which is produced combines with and fixes the dye.

All of these processes are identical in principal, the object being to deposit some insoluble metallic compound within the fiber; when now the mordanted material is treated with a solution of a suitable dye the latter unites with the metallic hydroxide, forming a colored compound which is fixed in the fiber. The colored substances produced by the combination of dyes with metallic hydroxides are termed lakes and those dyes which form lakes are called acid dyes.

Tannin is an example of a different class of mordants, namely, of those which are employed with basic dyes, such as malachite green and rosaniline. Its use depends on the fact that being an acid it combines with dyes of a basic character, forming with them insoluble colored salts, tannates, which are thus fixed in the fiber. The fabric is first mordanted by passing it through a weak solution of tartar emetic or stannic chloride, which converts the tannin into an insoluble antimony or tin stannate, and thus fixes it in the fiber.

When an insoluble leuco-compound, which is very readily reconverted into the dye on oxidation, it may be applied to fabrics in a special manner, as, for example, in the case of indigo blue. Indigo blue is insoluble in water, but on reduction it is converted into a readily soluble leuco-compound known as indigo white. In dyeing with indigo white a solution is prepared by reducing indigo suspended in water with grape sugar and sodium hydroxide and the fabric is then passed through this solution, whereupon the indigo white diffuses through the walls of the fiber. On subsequent exposure to the air the indigo white is reconverted into indigo blue by oxidation and the insoluble dye is thus fixed in the fiber.

From the above description it will be seen that many different materials are used in the dyeing operations and that any direct discharge of these compounds would be a loss to the manufacturer. The waste is therefore small from dyeing operations, but it is necessary to wash the goods after dyeing and small amounts of the dye carried from the vats on the goods give intense color to these wash waters. At times also it becomes necessary to change colors in the vats, and while it is the aim to use just enough dye solution for the pieces to be dyed, at times some is left over and the wastes become bright colored from these discharges. On other occasions it may be necessary to discharge vats of mordants and the wastes at various times will contain these various solutions. After the process called "one bath dyeing" the vats are always discharged as the color strength is gone.

The wastes from the finishing operations will therefore consist of a soapy liquid, gray and turbid, oftentimes covered with froth and scum containing considerable suspended matter and at times will be highly colored from the dye discharged from the dye house.

Besides the oil, dirt and spent solutions used in the scouring, fulling, bleaching, dyeing and washing operations, the waste also contains varying quantities of fiber taken out of the goods in the various operations. This waste fiber may in some cases be made to yield considerable return if suitable screening devices are installed to recover it. This fiber also interferes in purification processes, increasing the quantity of sludge in settling tanks and forming a mat on the surface of filters which soon clogs them. In all cases as much of the waste fiber as possible should be removed before treating the waste.

The Manufacture of Shoddy.—In recent years a class of woolen goods known as shoddy has come into greater use. Shoddy is a name generally applied to goods made from woolen rags which have been split up into the original fiber, dyed and again made into cloth. The rags used are obtained from every available source and arrive at the mill containing much dirt and dust and considerable other foreign matter. They are first sorted and then treated with dilute sulphuric acid or hydrochloric acid (carbonized) to disintegrate the cotton fiber and other vegetable matter which it may contain. The rags are then dried and dusted to remove this carbonized material. The wool fiber obtained is then washed and treated with enough alkali to neutralize the acid left from carbonizing. The wash water from the first part of washing constitutes one of the worst wastes from the manufacture of shoddy. The first discharges contain considerable organic matter and dirt, but as the washing continues becomes less objectionable and the last to be discharged is nearly clear. After washing, the fiber is dried and then passed through a picker, which produces the woolen fiber which is used in the manufacture of shoddy goods. Shoddy stock is usually dyed in tubs before it is made into cloth.

With the increasing use of shoddy the process of manufacture and the wastes resulting are becoming more and more important. In many mills it will now be found that a complete line of shoddy goods is being produced.

The wastes from the manufacture of shoddy goods consists of the dirty wash waters from the cleaning of the rags after carbonizing, from the oil used in the weaving operations and which may in some cases amount to as much as 30 per cent of the weight of the goods and from wash waters from the finishing of the goods or dyeing of the shoddy stock.

In the following tables will be found analyses of the wastes from the different operations in finishing woolen goods. Tables I and Ia are composed of analyses made by the Massachusetts State Department of Health in their study of stream pollution and trade waste disposal, these studies being made under the direction of X. H. Goodnough, Chief Engineer of the department. Tables II and III are the results of examinations of the wastes from English textile mills by Wilson and Calvert and published in Trade Waste Waters. These two tables show very clearly the difference in the wastes when the heavier liquors containing oil and grease are separated from the wash waters:

From the above analyses it is at once apparent that the character of the individual wastes from any one operation varies between wide limits, also the composite wastes from various mills are very different in character, depending on the kind of goods being finished. The fats in these analyses represent the oil added in the picking and taken up in the spinning and weaving operations and are many times less than in the waste from wool washing. The amount of potash in this class of waste will also be limited to the amount that may have been added in the scouring and cleaning solutions, as all the potash present in the raw fiber will have been removed in the preliminary scouring.

It is at once apparent that this class of waste does not offer the possibilities of profit from grease and potash recovery that wool washing wastes do. Considerable oil which has been added to assist in the production of the finished material may, however, be recovered, and at several plants has returned quite a profit to the manufacturer.

Sewage purification methods are available for the purification of these wastes when in a dilute form and when they do not contain the heavy liquors from wool washing and the washing of heavy woolen cloth after weaving. Where such liquors are produced and discharged from the mill it is economy to separate them from the others and recover the grease and potash, or the grease alone, as already described, for the treatment of this class of wastes. The sale of the recovered material will pay for the cost of operating that part of the plant and may return a slight profit to go toward the cost of the plant. It will, however, remove from the wastes that material, grease, which interferes with sewage treatment methods so that the liquor remaining from the recovery process can be treated along with the wash waters, dye waters, etc., by sewage methods.

Sewage Purification Methods.—Experiments on the treatment of the wastes from woolen mills were made by the Massachusetts State Department of Health under the supervision of H. W. Clark, chemist, and the results published in their annual reports. Following is an outline of their work and the results obtained:

Experiments were made on the wastes from a mill in which woolen cloth was washed, dyed and afterwards washed again. Two small experimental filters were operated on this waste. Each filter was constructed of 3 ft. of sand having an effective size of 0.28 m.m. One filter was operated at a rate of 100,000 gal. per acre per day for two months with the raw waste and then for two months more at a rate of 55,000 gal. per acre per day with the supernatant liquor after chemical precipitation.

The use of 3,500 lb. of lime per 1,000,000 gal. of waste caused a removal of 80 per cent of the nitrogen determined as albuminoid ammonia, over 90 per cent of the matters determined by oxygen consumed together with about 70 per cent of the organic matter determined by loss on ignition. As the waste amounted to 200,000 gal. per day, chemical precipitation would have cost $2.00 per day.

A second filter was operated for four months with the waste, after sedimentation, without chemical treatment, at a rate of 100,000 gal. per acre daily. The effluent of both filters was always clear and non-putrescible, but sedimentation alone seemed to give as good results as chemical precipitation.

The character of the wastes and the results of the operation of these filters are shown in Table IV.

The wastes from a second mill, consisting of the liquors from wool scouring, spent dye liquors, wash waters and wash waters from a shoddy mill were experimented with.

Three filters, one a trickling filter 6 ft. in depth, of broken stone; the other two sand filters, 3½ ft. and 2 ft. in depth, of sand, having an effective size of 0.26 m.m., were operated with the waste. The effluent of the trickling filter was very little different than the applied liquor. The 2-ft. sand filter was operated for three weeks at a

TABLE I.—ANALYSES OF THE WASTES FROM THE FINISHING OF WOOLEN GOODS.

Parts per Million.

Source and character of waste.	Total residue.		Loss on ignition.		Ammonia.		
	Total.	Suspended.	Total.	Suspended.	Free.	Albuminoid. Total.	Albuminoid. Suspended.
SCOURING AND RINSING.							
Woolen Goods—							
Satinets cloth scour	9612	2604	6076	2228	3.6	88.4	49.0
rinse after	24126	3032	3620	2554	0.3	16.1	13.1
cloth scour	56340	17260	33320	13050	23.0	283.0	169.0
rinse after	322	166	210	138	.02	3.2	2.6
Shoddy cloth scour	16050	6320	10570	5600	7.5	135.0	63.0
first part rinse	1502	612	1006	586	0.1	16.0	11.2
second part rinse	182	26	68	24	.03	4.2	3.5
Average	342	146	222	142	.02	4.0	3.2
cloth scour	2454	1168	1898	1086	1.0	28.2	16.8
rinse after	1312	284	984	200	1.0	11.0	7.1
scour and rinse	294	76	148	61	0.3	2.8	1.8
cloth scour	33490	23880	23760	19160	37.0	670	330
first rinse	2240	724	1700	650	0.6	57	48
second rinse	1188	894	984	814	0.5	19	16
final rinse	160	28	120	12	0.5	6	5
scour and rinse	200	28	96	18	2.1	3.8	2.9
first cloth rinse	1300	236	888	228	3.6	10.2	7.6
second cloth rinse	242	25	57	23	2.8	2.6	2.2
Worsteds—							
first rinse	7168	.....	224	.....	13.6	8.2	0.4
rinse after soaping	984	234	406	190	11.2	5.0	3.3
wash on narrow goods	584	236	424	194	4.0	7.4	6.2
White Worsteds—							
first wash	1434	370	762	250	36.4	13.2	8.8
second wash	656	94	276	72	14.6	4.0	2.4
Flannel—							
first part rinse	26290	7260	18480	7120	7.2	112.8	75.2
last of rinse	168	10	60	8.0	0.2	1.1	0.1
rinse after sulphur bleach	2010	.....	300	.....	6.0	9.4	0.6
Felting, rinse after scour	1122	146	370	126	5.0	14.8	6.2
Carpets, yarn scour	7190	2884	5230	2462	21.0	83.0	45.4
rinse	288	.....	150	.....	2.0	3.5	0.9
DYEING AND WASHING.							
Satinets—							
Spent Oxford dye	1932	56	242	38	2.5	6.3	3.3
Spent blue dye	20408	112	2220	92	8.6	41.2	2.0
Spent brown dye	19368	50	216	32	0.7	5.9	1.3
Shoddy, Spent dye	5142	.....	408	.....	14.2	12.9	0.5
Spent dye	8080	.....	368	.....	1.8	17.0	3.4
Spent dye	19670	.....	5628	.....	7.4	29.0	8.4
First rinse after direct dye	117	.....	.....	.....	0.5	0.8	0.4
Second rinse	66	.....	.....	.....	0.1	0.4	0.1
Rinse spent Union dye	10704	520	2376	174	8.4	24.4	2.0
Rinse after dye	1456	4	108	8.0	8.0	6.4	1.7
Rinse after first bath alizarine dye	82	.....	22	.....	0.5	1.1	0.7
Rinse after second bath alizarine dye	91	8	30	7.0	0.9	1.1	0.5
Shoddy—							
Rinse after black dye	7038	112	556	80	17.6	20.8	2.6
Worsteds—							
Second rinse after Union dye	7974	5	.....	.....	8.0	0.4	.04
Rinse after acid dye	2444	36	404	32	8.4	2.3	0.3
Felting—							
Acid dye and rinse	2512	.....	.....	.....	0.4	1.2	0.4
Union dye and rinse	7724	.....	176	.....	0.5	2.4	1.6
Carpets—							
Spent yarn dye	12936	.....	1298	.....	39	61	4

TABLE Ia.—ANALYSES OF MISCELLANEOUS WASTES FROM THE MANUFACTURE OF WOOLEN GOODS.

Parts per Million.

Source and character of waste.	Total residue.		Loss on ignition.		Ammonia.		
	Total.	Suspended.	Total.	Suspended.	Free.	Albuminoid. Total.	Albuminoid. Suspended.
Washing rags for shoddy—							
5 minutes after start	1651	.....	940	.....	....	....	....
20 minutes after start	871	.....	505	.....	....	....	....
35 minutes after start	467	.....	266	.....	....	....	....
50 minutes after start	338	.....	211	.....	....	....	....
65 minutes after start	281	.....	180	.....	....	....	....
Composite sample	588	.....	350	.....	....	....	....
Mixed wastes—							
Cloth washing and dyeing	1187	.....	476	.....	1.2	8.9	....
Washing, dyeing and boiling cloth	2704	.....	1215	.....	3.9	21.9	....
Cloth scour, milling and washing	3196	992	.....	.....	3.2	23.3	....
Fulling liquor and wash water	8380	3380	4540	1000	....	24.0	....

TABLE II.—ANALYSES OF THE WASTES FROM THE FINISHING OF WOOLEN GOODS.

Parts per Million.

	Solids			Nitrogen					
	Total.	Suspended.	Soluble.	Ammoniacal.	Albuminoid.	Organic.	Alkalinity.	Hardness.	Fatty matter.
Mixed wastes scouring, milling and washing woolen goods	3,196	992	2,204	3.2	23.3	45.0	1,039	...	1,392
Mixed scouring refuse, fancy woolens	14,122	7,138	6,984	11.1	79.9	155.4	3,031	111	7,140
Wash after first scour	1,028	468	560	1.6	9.7	36.9	233	34	241
Wash after second scour	587	251	336	0.8	10.0	20.1	116	60	81
Wash after milling	769	355	414	26.0	17.2	40.3	180	25	162
Thicker suds from piece scouring, yarn scouring and dyeing	11,334	5,572	5,762	85.8	74.7	191.6	2,713	...	4,268
Washing off waters	4,948	2,078	2,870	36.2	25.9	76.8	1,208	385	1,369
Flannel—									
First wash after scour	7,866	5,060	2,806	11.4	....	80.3	.....	...	.....
Second wash after scour	1,560	944	616	15.3	....	20.6	.....	...	.....
Third wash after scour	1,330	770	560	0.9	....	11.7	.....	...	.....

Analyses from Wilson and Calvert Trade Waste Waters.—No. 1 from Rowley Mills. Nos. 2-5 from Huddersfield Mill. Nos. 6 and 7 from Hopton Mill. Nos. 8-10 source not given.

TABLE III.—ANALYSES OF WASTES FROM THE FINISHING OF WOOLEN GOODS.

Parts per Million.

Character of waste.	Solids			Nitrogen			Oxygen abs. 80/N per sol.	Total hardness as $CaCo_3$.
	Total.	Suspended.	Soluble.	Ammoniacal.	Albuminoid.	Organic.		
Washing off waters	1,408	888	520	....	9.6	13.0	162.5	...
Dye wastes	1,932	259	1,673	5.7	6.7	20.1	102.8	152
Composite of above	2,519	270	2,249	6.3	5.8	9.7	108.3	630
Dye wastes	1,919	283	1,633	7.9	5.7	22.0	153.8	495
Final washing off waters from piece scouring and waste dye waters	1,854	116	1,738	11.3	2.2	5.6	67.5	284
	1,981	187	1,794	14.5	2.7	3.7	91.2	415
Final washing off waters from piece scouring and wastè dye waters	858	214	644	14.2	2.3	7.6	43.3	150
	1,621	441	1,180	7.7	5.0	12.6	119.3	120
Acid waters after grease recovery and dye waters mixed	2,642	592	2,050	2.6	9.4	15.7	179.0	850
	1,968	282	1,686	4.5	4.0	10.7	144.4	798
	1,996	502	1,494	13.7	1.3	9.8	163.8	750
Acid waters after grease recovery, final washing off waters from piece scouring and dye waters	534	214	320	29.7	0.7	8.3	8.2	147
	522	202	320	30.1	0.5	3.7	8.4	127
	536	219	317	33.3	0.7	8.3	7.6	118

Analyses from Wilson and Calvert Trade Waste Waters.—Analyses Nos. 1-3 from Wensleydale Mills. No. 4 from Dock Ing Mill. Nos. 5 and 6 from Bowling Dye Works. Nos. 7 and 8 from Livingston Mill. Nos 9 to 11 from Cheapside Mills. Ncs. 12 to 14 source not given.

TABLE IV FILTER OPERATING ON CHEMICALLY PRECIPITATED WASTES.

Parts per Million.

Source.	Total residue.	Total loss on ignition.	Free.	Albuminoid.	Nitrates.	Nitrites.	Oxygen consumed.
Raw waste	1,187	476	1.2	8.9	...	...	199
Applied waste	1,664	131	0.7	1.3	...	...	29
Effluent	1,218	87	0.5	0.95	0.7	.06	16
Per cent removal							
By precipitation	.....	72	38	85	...	...	85
By filtration	27	34	31	29	...	...	46
Precip. and filtration	.....	82	57	89	...	...	92
Filter Operating on Settled Waste.							
Raw waste	1,187	476	1.2	8.9	...	...	199
Applied waste	1,239	285	1.0	3.0	...	...	119
Effluent	1,053	104	0.2	0.7	0.0	...	24
Per cent removal—							
By sedimentation	.....	40	16	67	...	...	40
By filtration	15	64	79	75	...	...	80
Sedimentation and filt.	11	78	82	92	...	...	88

rate of 1,500,000 gal. per acre per day until it clogged. Three inches of sand were removed from the surface and the rate reduced to 1,000,000 gal. per acre per day, but it again clogged. The clogging was due to the fatty matters present in the scouring liquor. This serves to bring out strongly the necessity of the separation of the wastes containing the grease and its treatment for recovery. The 3-ft. sand filter was operated at a rate of 50,000 gal. per acre per day and then at a rate of 150,000 gal. per acre daily, with the effluent of the 2-ft. sand filter. This effluent was always clear and odorless, but was somewhat colored by the spent dyes in it.

The results of the analyses of the applied liquor and the filter effluents follow in Table V.

TABLE V.—RESULTS OF EXPERIMENTS WITH WOOLEN MILL WASTES.

Parts per Million.

	Raw waste.	Settled waste.
Unfiltered—		
Total solids	1,500	941
Loss on ignition	600	269
Fixed solids	900	672
Filtered—		
Total solids	1,080	.....
Loss on ignition	302	.....
Fixed solids	778	.....
Ammonia—		
Free	5.8	4.8
Albuminoid total	8.0	3.1
Albuminoid suspended	3.0	.....
Oxygen consumed	81.4	36.1

ANALYSES OF SAND FILTER EFFLUENTS.

	Two-foot sand filter.	Three-foot sand filter.
Free ammonia	2,347	3,839
Albuminoid ammonia	1.614	.703
Nitrates	.3	3.7
Nitrites	.004	.092
Oxygen consumed	18.8	12.9

These results seemed to indicate that these wastes could be purified without any great difficulty by sand filtration at rates up to 500,000 gal. per acre per day. Sedimentation in ample settling basins should precede filtration. The wastes from the wool scouring processes should have a separate treatment before being added to the other wastes.

The wastes from a third mill consisting of the wash waters from washing, boiling and dyeing heavy woolen cloth were experimented upon. The wastes consisted of about one part spent dye and thirteen parts wash waters.

Two filters were operated with this waste. Number 1 was 3 ft. in depth of sand having an effective size of 0.28 m.m. and was operated at a rate of 100,000 gal. per acre daily with the supernatant liquor from the waste after treatment with 5,000 lb. of lime and 5,000 lb. of copperas per 1,000,000 gal. After a few weeks' operation the rate was cut to 50,000 gal. per acre daily. Filter number 2 was 4 ft. deep and consisted of sand having an effective size of 0.25 m.m. The supernatant liquor after sedimentation only was applied to this filter. The rate at first was 100,000 gal. per acre daily, but later was changed to 50,000 gal. per acre daily. The effluent was always clearer than the effluent of number 1 and was always non-putrescible. The experiments indicated that this class of waste could be purified by sedimentation and filtration through 3 or 4 ft. of sand at rates not to exceed 50,000 gal. per acre per day. The results of these experiments are given in Table VI.

TABLE VI—RESULTS OF EXPERIMENTS ON THE WASTES FROM WOOLEN MILLS.

Parts per Million.

FILTER NO. ONE.

			Ammonia.		Nitrogen as		
Source.	Total residue.	Total loss on ignition.	Free.	Albuminoid.	Nitrates.	Nitrites.	Oxygen consumed.
Raw waste	2,704	1,215	3.9	21.9	...	...	181.3
Applied waste	2,348	669	4.2	6.7	...	...	111.3
Effluent	1,768	22	.35	1.5	1.0	.03	19.3
Per cent removed	.....	67	...	78	...	...	83
FILTER NO. TWO.							
Raw waste	2,704	1,215	3.9	21.9	...	...	181.3
Applied waste	2,645	1,111	3.9	9.5	...	...	142.0
Effluent	1,476	175	.1	.8	0.0	.001	15.0
Per cent removed	.....	84	...	92	...	...	89

The wastes experimented upon at a fourth mill consisted of the wash waters from the washing and dyeing of cloth and dyeing of raw cotton. In cloth washing the goods were first saturated with a soap solution in the fulling machines and then washed for half an hour. The dyes used were heavy logwood and aniline dye.

A mixture of the worst wastes from the mill were applied to a sand filter 3 ft. in depth, the sand having an effective size of 0.25 m.m. at a rate of 100,000 gal. per acre per day. The waste was turbid, pinkish, non-putrescible and deposited but a small amount of matter on standing. The filter removed 85 per cent of the organic matter, as indicated by albuminoid ammonia, and 89 per cent, as indicated by oxygen consumed. The effluent was always clear, colorless and non-putrescible.

The results of the operation of this filter are given in Table VII.

TABLE VII.—PARTS PER MILLION.

			Ammonia.		Nitrogen as		
Source.	Total residue.	Total loss on ignition.	Free.	Albuminoid.	Nitrates.	Nitrites.	Ogygen consumed.
Raw waste	1,623	624	1.0	5.8	...	...	114
Applied waste	1,506	546	.7	3.4	...	...	8.5
Effluent	1.153	126	.3	.5	.1	.02	1.0
Per cent removed—							
Sedimentation	7	12	30	42	...	...	22
Filtration	23	77	60	85	...	...	89
Sed. and filtration	29	80	72	91	...	...	91

In 1904, 1905 and 1906 experiments relative to the purification of the wastes from a carpet mill were made. Waste liquors were produced from the scouring of wool and yarn and from dyeing and washing. The waste was a heavy soapy liquor, a semi-emulsion of fat, dirt and soap containing 20,000 to 30,000 parts of suspended matter per million, or from seventy to one hundred times as much as in domestic sewage.

Sedimentation of the composite waste for 24 hours removed 50 per cent of the total nitrogenous matter and 60 per cent of the total organic matter. The common coagulants, unless applied in excessive amounts, had little effect on the organic matter remaining after sedimentation. Copperas and lime equal to 2,500 lb. per million gallons of waste removed 23 per cent of the nitrogenous matter and 35 per cent of the total organic matter left in the supernatant liquor after sedimentation. Copperas and lime equal to 5,000 lb. per million gallons removed 34½ per cent of the nitrogenous matter and 50 per cent of the total organic matter of the supernatant after sedimentation.

Seven filters of various materials were operated for about five weeks with the waste. Three of the filters contained sand having an effective size of 0.33 m.m. and were operated at rates varying from 100,000 to 500,000 gal. per acre per day. Three other filters, constructed of coke breeze, soft coal and charcoal were each operated at a rate of 500,000 gal. per acre daily, while a cinder filter was operated at a rate of 1,000,000 gal. with the supernatant liquor after 24 hours' sedimentation. The operation of these filters showed that:

> Sand filtration at low rates gave the best purification. Chemical precipitation followed by higher rates of sand filtration removed more

of the organic matter than plain sedimentation followed by sand filtration, but not enough more to pay for the chemicals used.

A cinder filter operated at a million-gallon rate gave nearly as good purification as a low-rate sand filter, but clogging made frequent removal of the cinders necessary.

A coke breeze filter at a rate of 500,000 gal. gave as good results as a cinder filter at a rate of a million gallons and nearly as good results as a low-rate sand filter. None of the filters removed much of the color of the applied liquor.

Additional experiments, consisting of filtration through sand and cinders, were carried on for a period of seven months. A cinder filter 18 in. in depth was operated at a rate of 500,000 gal. per acre daily with the supernatant liquor after the waste had settled for 24 hours and the effluent of the cinder filter was applied to a sand filter 27 in. deep at a rate of 100,000 gal. per acre daily. These filters removed 62 per cent of the nitrogen as albuminoid ammonia, 65 per cent of the organic matter determined as oxygen consumed, 23 per cent of the total solids and 56 per cent of the volatile solids.

A second series of filters, consisting of three sand filters, each 42 in. deep, of sand having an effective size of 0.28 m.m., received the supernatant liquor after sedimentation at a rate of 100,000 gal. per acre daily. The effluent of the first filter was applied to the second filter and the effluent of the second applied to the third filter. The rates on all of the filters was 100,000 gal. per acre per day. The results of triple sand filtration expressed in percentage removal are given in Table VIII.

TABLE VIII.

Filter number.	Ammonia—Free.	Ammonia—Albuminoid.	Kjeldahl nitrogen.	Oxygen consumed.	Solids—Total.	Solids—Loss.	Solids—Fixed.
1	53	56	66	65	24	53	7
2	77	71	77	76	40	72	22
3	78	81	86	84	51	79	33

A single sand filter, the same depth as the three filters above, but operated at a rate of 33,300 gal. per acre per day, or at a rate per unit of surface similar to the combination of three above, gave the following percentage removals:

Ammonia—Free.	Ammonia—Albuminoid.	Kjeldahl nitrogen.	Oxygen consumed.	Solids—Total.	Solids—Loss.	Solids—Fixed.
76	78	84	82	46	72	30

While the applied wastes quickly putrefied, the effluents from all the filters, with the exception of the shallow cinder filter, were clear and green in color and perfectly stable, being kept for weeks without putrefying. The character of the untreated waste, the applied waste after sedimentation and the filter effluents from the various filters is shown in Table IX.

TABLE IX.—PARTS PER MILLION.

AVERAGE ANALYSIS—UNTREATED WASTE LIQUOR.

Residue—Total.	Residue—Dissolved.	Loss on ignition—Total.	Loss on ignition—Dissolved.	Ammonia—Free.	Ammonia—Albuminoid—Total.	Ammonia—Albuminoid—Dissolved.	Kjeldahl nitrogen.	Oxygen consumed.
4,256	3,310	2,301	1,418	16.6	25.2	8.5	48.7	494

APPLIED WASTE (SUPERNATANT AFTER 24 HOURS' SEDIMENTATION).

Solids—Total.	Solids—Loss.	Solids—Fixed.	Ammonia—Free.	Ammonia—Albuminoid.	Kjeldahl nitrogen.	Nitrates.	Oxygen consumed.
2,007	897	1,110	6.2	8.5	19.5	....	126

FILTER EFFLUENTS.

Filter.	Operated with.	Rate.	Depth, in inches.	Size of sand, m. m.	Solids—Total.	Solids—Loss.	Solids—Fixed.	Ammonia—Free.	Ammonia—Albuminoid.	Kjeldahl nitrogen.	Nitrates.	Oxygen consumed.
Cinder	Settled waste	500,000 250,000	18	....	1,471	429	1,042	4.5	4.8	11.2	0.5	82.4
Sand	Effluent of cinder filter	100,000	27	0.28	1,299	182	1,117	2.1	2.2	6.5	1.7	36.4
Sand (a)	Settled waste	100,000	42	0.28	1,376	213	1,163	5.3	2.5	4.3	0.5	38.2
Sand (b)	Effluent (a)	100,000	42	0.28	1,183	124	1,059	0.9	1.6	2.9	3.2	22.5
Sand (c)	Effluent (b)	100,000	42	0.28	1,012	104	908	0.7	1.1	1.9	3.8	17.7
Sand	Settled waste	33,300	42	0.28	1,127	141	986	1.2	1.3	2.0	3.0	21.7

The results of these experiments appeared to show that a good effluent could be obtained by the use of settling tanks with one day's storage capacity, followed by sand filtration of the supernatant liquor at a rate up to 50,000 gal. per acre per day, sedimentation removing 50 per cent of the total organic matter and filtration removing 75 per cent of that remaining.

Shoddy Mill Wastes.—In 1906 the Massachusetts State Department of Health made experiments upon the wastes from a shoddy mill, consisting of the water from the washing of rags after carbonizing and the spent dye liquors from dyeing. The wastes from dyeing were very small. The wash waters from the carbonizing process contained considerable acid, 250 to 1,200 lb. of lime per 1,000,000 gal. of waste being required to neutralize it.

This waste after neutralization was applied for two months at the rate of 100,000 gal. per acre per day to a filter 3 ft. in depth, the sand having an effective size of 0.28 m.m. The effluent was always clear, colorless, non-putrescible and nitrification in the filter was active. The average analyses of the raw waste and the filter are given in Table X.

TABLE X.—PARTS PER MILLION.

Source.	Total residue.	Total loss on ignition.	Ammonia. Free.	Ammonia. Albuminoid.	Nitrogen as Nitrates.	Nitrogen as Nitrites.	Oxygen consumed.
Raw waste	717	369	6.4	4.3	..	...	44
Applied waste	536	101	6.2	1.3	..	...	19
Effluent	611	94	0.2	0.5	10	0.4	7
Per cent removal—							
Sedimentation	25	72	3	70	..	...	56
Filtration	..	7	97	59	..	....	65
Sed. and filtration	15	75	97	88	..	...	85

Further experiments were made upon this class of wastes in 1908. The waste before being applied to the filter was first settled and a small amount of suspended matter settled out. The liquid was then filtered through sand, first at a rate of 100,000 gal. per acre per day, and later at a rate of 150,000 gal. per acre daily. The effluent was always satisfactory and well nitrified. Table XI shows the results of sedimentation and filtration:

TABLE XI.—FILTRATION OF SHODDY MILL WASTES.

Parts per Million.

Source.	Ammonia—Free.	Ammonia—Albuminoid.	Nitrogen as—Nitrates.	Nitrogen as—Nitrites.	Oxygen consumed.	Hardness.
Raw waste	9.5	4.1	....	...	31	...
Applied waste	8.0	1.3	....	...	10	130
Effluent	0.8	0.6	12.8	.02	8	15

The Filtration of Dye Liquors.—The treatment of highly colored dye liquors has been studied at the Massachusetts State Department of Health's experiment station at Lawrence, Mass., along with other trade waste problems.

Chemical treatment of the wastes by precipitation with lime, ferric chloride, copperas, iron, alum, etc., was studied. The best results were obtained with lime and ferric chloride in various proportions, the greatest amount never being over one ton per 1,000,000 gal., which amount often removed practically all of the coloring matters.

The supernatant liquor after chemical treatment was applied to two sand filters. One sand filter, 4 ft. in depth, with sand having an effective size of 0.27 m.m., was operated at a rate of 2,000,000 gal. per acre per day and gave the following average analyses for six months:

Parts per Million.

Color	Pale yellow
Free ammonia	3.73
Albuminoid ammonia	0.93
Nitrates	1.20
Oxygen consumed	15.4

A filter of soft coal ashes 4 ft. deep, operated at a rate of 2,000,000 gal. per acre per day, gave the following average analyses:

Parts per Million.

Color	Light yellow
Free ammonia	5.00
Albuminoid ammonia	1.05
Nitrates	0.30
Oxygen consumed	13.5

The sludge produced by the chemical treatment of the dye liquors with precipitants was treated on a filter 2 ft.

in depth, composed of soft coal ashes, at a rate of 40,000 gal. per acre daily. The dose usually disappeared in 24 hours, but during the five months it was in operation it was necessary to remove the sludge from the surface four times. The effluent was clear and colorless and contained only a small amount of the organic matter, as shown by the following average analyses:

	Parts per Million.
Turbidity	None
Color	0.5
Free ammonia	3.52
Albuminoid ammonia	0.10
Nitrates	1.70
Nitrites	.001
Oxygen consumed	1.00

Three other filters were operated with the waste dye liquor from one of the mills at Lawrence. Filter number 1 was a sand filter 5 ft. deep and was operated at a rate of 50,000 gal. per acre per day for seven months and produced a clear effluent having a pale yellow color and removed 95 per cent of the organic matter. Filter number 2, a coke contact filter, operated at a rate of 400,000 gal. per acre daily for three months, removed less color and 80 per cent of the organic matter. Filter number 3, a trickling filter of broken stone, operated at a rate of 540,000 gal. per acre daily, removed still less color and 70 per cent of the organic matter. Following, in Tables XII and XIII, are the averages of the applied liquor and the effluents of these three filters.

TABLE XII.—FILTRATION OF DYE LIQUORS.

Parts per Million.

	Appearance		Ammonia			
Source.	Sediment.	Odor.	Free.	Albuminoid.	Nitrates.	Oxygen consumed
Dye liquor	Decid.	Strong	3.28	2.62	0.0	63
Sand filter effluent.	None.	None.	0.22	0.19	2.9	4
Contact filter effl.	V. Sl.	V. Sl.	2.41	0.67	0.4	11
Trickling filt. effl.	V. Sl.	Sl.	2.61	1.03	0.9	19

TABLE XIII.—AVERAGE PERCENTAGE REMOVAL OF ORGANIC MATTER FROM DYE LIQUOR BY VARIOUS TREATMENTS.

	Per cent removed	
	Albuminoid ammonia.	Oxygen consumed.
Chemical treatment—		
Two hours' sedimentation	21.3	55.9
Sixteen hours' sedimentation	46.0	64.0
Effluent of sand filter after chemical treatment	78.0	88.0
Effluent of sand filter without chemical treatment	94.0	96.0

Stabler and Pratt, in their investigations of the disposal of wastes from textile industries, made experiments upon the filtration of dye liquors from the R. D. Mason Company's plant at Pawtucket, R. I. The dye liquors treated here were from the dyeing of cotton yarn. While the operations and the colors used in dyeing various classes of goods may differ, the waste liquors from all dyeing operations are more or less similar. This waste varies considerably, even through the day, because of the many and different processes being carried out in the dye house, and consists of relatively small amounts of spent dye in large volumes of water. Table XIV shows an average and the maximum and minimum determinations of the waters experimented on at Pawtucket.

TABLE XVI.—ANALYSES OF THE LIQUOR FROM THE DYE DRAIN OF THE R. D. MASON COMPANY, PAWTUCKET, R. I.

Milligrams per Liter.

	Average analysis.	Maximum determination.	Minimum determination.
Solids—			
Total	1,470	1,576	570
Dissolved	.....	1,482	612
Loss on ignition			
Total	450	764	206
Dissolved	.....	340	168
Free ammonia	1.8	4.9	0.3
Organic nitrogen	5.2	15.5	1.0
Oxygen consumed	240	660	85

Analyses by G. H. Pratt.

The dye liquors as represented above were treated on sand filters. Two beds, with a depth of 3½ to 4 ft. of sand, having an effective size of 0.24 m.m. and a uniformity coefficient 3.4, were operated with this waste. Filter number 1 was first operated at a rate of 100,000 gal. per acre per day, during which time it gave an effluent of good appearance free from color and low in organic content. After a little less than two months' operation the rate was changed to 400,000 gal. per acre daily, and after about six weeks' operation the rate was again reduced to 100,000 gal. During the latter operation the effluent showed color and the analyses were unsatisfactory, the high rate of filtration, combined with extreme cold weather, causing the deterioration.

Filter number 2 was operated at a rate of 200,000 gal. per acre daily throughout the experiments. The same deterioration of the effluent was noticeable during cold weather. The effluent contained nitrites, but nitrates were never high, although present at times.

The organic purification of dye liquors by filtration are given in Table XV.

TABLE XV.

	Milligrams per liter.			Per cent removal.		
	Free ammonia.	Organic nitrogen.	Oxygen consumed.	Free ammonia.	Organic nitrogen.	Oxygen consumed.
Waste from drain	1.8	5.21	240	..	..	..
Av. of 5 analyses, effluent filter No. 1, rate 100,000 gal.	.81	.37	6.4	55	93	97
Av. of 5 analyses, effluent filter No. 2, rate 200,000 gal.	.89	.67	11.8	51	87	95

From these experiments it appeared that about 95 per cent of the organic matter and nearly all of the color of spent dye liquors could be removed by sand filtration at rates not to exceed 100,000 gal. per acre per day.

Partly because of the limited sites available and partly to obtain a partial purification of waste dye liquors and wash waters which with the addition of fresh water could be used again in the mills, numerous patented apparatus have been devised along the lines of water purification principles, and many of these have been installed, more particularly at English mills. Among these may be mentioned Waite's apparatus, Mackey's apparatus, Watson's plant, Archbutt-Deeley system, and Bell's apparatus. The purification of the trade wastes in all of these depends upon chemical precipitation, followed by sedimentation, or sedimentation and straining through filters of various materials. The precipitants used are lime, alumino-ferric, aluminum sulphate and soda, or combinations of the above. The first two systems depend upon sedimentation in cylindrical settling tanks, the upward velocity being reduced so that the precipitated sludge collects in the bottom of the tank, from which it is discharged onto sludge drying beds. The next two systems have rectangular settling tanks and sludge drying beds. Bell's apparatus is designed as a rapid sand filter plant and consists of a cylindrical settling tank and filter of the rapid type, provided with wash water devices, a strainer system, stirring apparatus, etc.

The actual purification obtained by these plants other than the removal of suspended solids is not very high, and probably not as great as could be obtained by chemical treatment and sedimentation in ample settling basins of the ordinary type. The removal of the suspended matter and partial purification does, however, make the wastes available for reuse and they are so used at several plants, being a source of profit both from the saving on the cost of water and by its conservation in times of drought when shutting down the plant might be necessary.

A study of the experiments on the treatment of this class of waste liquors indicates that the wastes from the finishing of woolen goods can be treated by sewage methods; that is, by sedimentation and filtration, or straining, provided those wastes which contain greese and which clog filters of this kind are treated separately. Excluding this latter class of waste, the wash waters and the waters containing the spent dyes can be purified by sedimentation, followed by filtration through sand at a rate not to exceed 100,000 gal. per acre per day. At this rate 78 to 92 per cent of the organic matter determined by albuminoid ammonia, 83 to 89 per cent as determined by oxygen consumed and about 80 per cent of the organic and other matters determined by loss on ignition can be removed from the waste.

Shoddy wastes neutralized, settled and treated by filtration, can be purified at a rate of 100,000 gal. per acre per day.

For the dye liquors alone the rate of 100,000 gal. per acre daily on sand filters will remove nearly all of the color and about 95 per cent of the organic matter.

Where the mill discharges wastes from the washing of woolen cloth, containing considerable grease, it is recommended, as already stated, that this be separated from the other wastes and be treated for the recovery of the grease and the acid waters resulting, after neutralization, be treated with the wash waters by filtration. The method proposed for the recovery of grease, as already described in another article, is the cracking process. By the recovery of this grease the return will be at least enough to pay for the operation of this portion of the works and will remove from the wastes the grease, which interferes with sewage methods.

The sale of grease from a plant at Pittsfield, Mass., already described, where the wastes from scouring were treated, showed a slight profit over the operating expenses, and a similar plant at Barre, Mass., was doing about the same.

The following two cases are taken from Wilson and Calvert in Trade Waste Waters and show the cost of operating such plants and the return from the grease recovered at English mills where woolen goods are finished. It is realized that English conditions are very different from those in this country and that the profits obtained there cannot be realized here, but the costs of operation will give some idea of what might be expected.

At the first mill heavy woolen goods were manufactured. During a year's operation 4,000 pieces were made, each 80 yards in length; 1,000 gal. of water were used per piece. The goods weighed 30 to 40 oz. per yard. The oil used in the manufacture amounted to 59.5 tons, which was recovered in the plant and reused with 16.8 tons purchased. The soap used cost $67 and amounted to 1,568 lb., of which 784 lb. may be reckoned as oil, making a total of 76.6 tons of oil in the waste. Forty tons of soda ash were used in the scouring, costing $897.34. The piece scouring wastes were treated at this plant by first being passed through a screening apparatus to recover flocks and then pumped to the recovery plant, treated with acid to separate the grease and the acid liquor neutralized and strained through a cinder filter.

Operating expenses—	
Lime per year	$ 5.35
Labor (one man @ $7.30 per week)	389.32
Acid	206.34
Steam and water for presses	243.33
Cloth for magma	7.54
Total	$ 851.88
Returns—	
Oil recovered	$2,607.22
Flocks recovered	40.15
49 tons pressed cake	109.01
Total	$2,756.38
Profit and loss account—	
Interest and depreciation, 10% on $2,740	$ 274.00
Operating costs	851.88
Total	$1,125.88
Annual profit	1,630.50

A second mill extracts the grease from the thicker suds from scouring fancy woolen and worsteds. The suds are passed through a screen box and patented flock catcher and then to a sump. The quantity of waste treated per day is 11,000 gal. The process used for grease recovery is the cracking method. Careful measurements, during which time 6,512 pieces, two-thirds woolen and one-third worsted, were scoured, showed 5 tons of flock recovered, 18 tons of oil used, 39 tons of soap used in scouring, of which half may be reckoned as oil, or 37.5 tons of oil were used; 46 tons of shoddy, or waste flock from carding, was sold, containing 30 per cent oil, or 13.75 tons; 17.5 tons of oil was recovered, or altogether 31.25 tons, or 83 per cent of that originally present in the waste. Following is the cost of recovery:

Interest, depreciation and operating expenses—	
7½% on buildings	$ 32.36
10% on plant	129.21
Labor	167.89
Acid, sacking, etc.	228.72
Steam	39.18
Total	$597.36
17½ tons of oil	$681.31
Returns—	
10 tons of pressed cake	14.60
Total	$695.91
Profit for period during which 6.512 pieces were scoured	98.55

Under conditions in this country these profits from the grease recovery would not be anywhere as great and would probably not pay operation expenses. In the case of the Pittsfield and Barre plant in this country operating on heavy wool scouring waste there is very little profit above operating expenses, and as the grease to be recovered from the washing of cloth would be considerably less, the return would also be proportionately smaller.

Summary.—To sum up: The final disposal of the wastes from wool finishing processes necessitates the separation of those containing grease and oil and the recovery of this material by acid treatment, and the sedimentation and filtration through sand or cinders of this waste combined with the other wash waters. The acid waters from the grease recovery should be neutralized and then mixed with the other waste waters, treated by chemical precipitation and sedimentation, after which in some cases they may be diluted with clear water and used again in the mill or the effluent from sedimentation can be filtered through sand or cinders.

MODERN BRICK ROAD CONSTRUCTION.

During the last five or six years much progress has been made in the further development of the vitrified paving block as well as in the methods of assembling the various materials used in the construction of brick roads. As a result of this progress it is now possible to secure for a smaller construction cost than has heretofore been paid, a smoother and consequently much more serviceable brick road than was obtainable by the old methods. The following particulars of modern brick road construction are taken from a paper by H. E. Bilger, Road Engineer, Illinois Highway Department, presented at the Conference in Highway Engineering at Kansas State Agricultural College, Manhattan, Kan.

Use of Old Foundations.

While old gravel and macadam roads can be used to great advantage as foundations for new brick surfaces, yet where such roads do not exist it seems more advisable that the foundation be of Portland cement concrete rather than either gravel or macadam even though of a 2-in. greater depth than the concrete. To utilize economically a gravel or macadam road as the base for a brick surface, there is required greater skill than where all the work is to be new. The establishment of the grade line is a delicate matter, inasmuch as a variation of only 1 in. may require either undue scarifying of the old surface or the unwarranted addition of new gravel or stone which should be united with the old. In order to establish this grade line properly it is frequently necessary to cross-section the old road at intervals of 50 ft., this depending of course upon the condition of the surface and the regularity of its profile. After having worked out the economic position of the grade line for each station along the line of the improvement, it is usually found necessary that the old surface be scarified to some extent in order that the higher places may be removed to make room for a sufficient quantity of the bed for the brick, and that the lower places may be filled up with fresh gravel or stone to avoid an excessive depth of this bed. The scarified, reshaped and rolled surface should conform with a permissible variation either way of ½ in., to the contour of the finished brick surface. This rolling should be done with the roller used for the subgrade work, and the compaction of the material should be most thorough.

The curb or edging, if used, may be built of concrete, having a width of from 4 to 6 in. at the top and from 6 to 8 in. at the bottom, the total height of the edging being from 12 to 15 in. While the edging is not really necessary as a pavement feature, yet its use is recommended because of the great convenience it offers as a guide for the templet used to locate to a nicety the areas to be scarified. The edging would be constructed, of course, before any of the road is scarified. With the edgings completed the road can be scarified and easily re-shaped and rolled to the proper cross-section and to an alignment conforming strictly with that of the edgings. Where edgings are not used it is necessary that there be set up true to line and grade temporary side forms that will carry the templet used as a guide for re-shaping the old road. From the expense of furnishing, setting up and later removing these temporary side forms there is added nothing of value to the completed pavement. In view of this fact, and also in view of the precision of alignment furnished by the concrete edgings, it will be appreciated why the edgings are generally used, and more particularly when it is considered that the top width of each edging acts simply as a substitute for a corresponding width of brick surface. Upon having thus prepared the old road to serve as a base, it is ready to receive the bedding course upon which the brick are set.

New Concrete Foundation.

While there may be found conditions that would warrant the construction of a new gravel or macadam foundation to carry a brick surface, yet these conditions are rare. The Portland cement concrete foundation constitutes the best that has yet been devised for brick roads. For the heaviest rural highway traffic in Illinois the fact seems demonstrated by experience that for an 18 ft. road a 4½-in. concrete base is entirely satisfactory, and for a 10-ft. one, 4 in. will suffice. These dimensions have been used under various soil and traffic conditions, and from every indication they are well on the side of safety.

It has further been demonstrated that the mixture for these bases need not be richer than 1:3½:6. This mixture has been used extensively with various qualities of aggregates. With reasonably satisfactory inspection of the work it is uneconomical to require that the fine and the coarse aggregates be used separately. The use of mixed aggregates, usually termed unscreened gravel, should be permitted with the restriction that one part by volume of cement shall be used to each 3½ parts of fine aggregate contained in the gravel, and that the ratio of the fine to the coarse aggregate shall not be less than 3½ to 6, nor greater than 7 to 6. With the fine aggregate ratio running at the permissible high figure, the value of the additional cement required would be about 7 ct. per square yard of base. It has been learned from specific cases that where unscreened gravel was shipped by rail for long distances the saving in the purchase and the transportation of the unscreened material as against separated aggregates amounted to more than 7 ct. per square yard of base. These were extreme cases in transporting materials a long distance, so under conditions where local materials are available the saving by the use of unscreened gravel would be still more. In the construction of country roads, usually having a width of from 10 to 18 ft., there is not conveniently available on the prepared subgrade a sufficient space to pile and use the aggregates separately.

The consistency with which the concrete for the base should be mixed depends upon whether the road is to be constructed monolithic, or with a cushion or bed of some substantial thickness between the base and the brick. If the latter method is to be followed the concrete can be of a rather wet consistency in order to keep down the cost of the work, but of course the consistency should not be such as would permit the separation of the aggregates. If the monolithic method is to be followed a comparatively dry consistency is required in order that the brick may be placed upon the concrete almost immediately. For monolithic work it is essential that the consistency of the concrete be uniform in order that local depressions may not develop due to the weight of the brick and the process of rolling.

Side Forms, Mortar Bed, Etc.

For the construction of a brick road having a sand-cement bed wood forms are permitted, inasmuch as these forms must remain in place until at least 24 hours after the pavement is grouted, which means about two weeks after the concrete base is laid. The expense of providing a sufficient length of steel forms to remain in place for two weeks would not be warranted by the advantages gained. For monolithic work, however, steel forms should be required, for the precision of alignment needed to harmonize with the smoothness of the pavement can usually be gotten only by their use.

The specifications of the Illinois Highway Department, edition of March, 1916, provide for both methods of constructing brick roads. By one method the brick are bedded upon a ¾-in. layer of dry mortar of a 1 to 4 mix, and by the other they are built monolithic with the base, a 3/16-in. layer of dry mortar of 1 to 3 mix being placed on the wet base as it is struck off. The use of the sand cushion as such has been abandoned.

By the former method, the order of procedure is practically identical with that in which a sand cushion is used, except that for any particular day's work only such a length of the base is covered by the mortar as can be covered with brick the same day. All of the brick laid on any particular day should be rolled on that day, even though the grouting may not be done until a day or so later. It is essential that the brick not be allowed to remain on the mortar bed over night without being rolled to a true and uniform surface, for if the mortar bed becomes moistened and sets, no reasonable amount of rolling can produce the smoothness desired.

By the monolithic method with concrete base, the mortar bed and the brick are all placed at practically the same time, or so nearly at the same time that within a period of from 5 to 15 minutes after the subgrade has been covered with concrete the brick are set to place. Usually not more than 10 or 15 lin. ft. of the base is ever exposed without being covered with brick.

Immediately upon placing the concrete on the subgrade it is roughly leveled off with shovels to the approximate thickness desired as determined by a light wood templet used as a gage. For the success of the monolithic construction the use of a rigid steel templet to strike off the base is essential. The templet thus far used has been of the multiple type, consisting of a 6-in. I-beam in front and a 6-in. channel behind, the two being spaced 2 ft. apart and riding on four rollers which are supported by the steel side forms. The lower or cutting edge of the front templet is located 3/16 in. below the corresponding edge of the rear templet. When a 4-in. brick is used the lower edge of the rear templet is set exactly 4 in. below the top of the steel forms. The space between the two templets is kept filled with dry mortar consisting of one part cement to three parts sand. As the templet is drawn forward by a cable attached to the mixer the base is struck off to a smooth surface and a 3/16th in. layer of the dry mortar is distributed evenly over the wet concrete.

Laying, Rolling, Grouting, Etc.

After the greater portion of the culling of the brick is done at the pile at the side of the road, the acceptable brick are carried to the setters on pallets and placed in stacks upon the brick pavement with the lugs all in one direction. Inasmuch as the final rolling of the brick should be done within 30 min. from the time the concrete is laid, it is important that the culling after their having been laid in the pavement be kept to a minimum. The brick are then set upon the mortar by men standing on the brick already laid. The rolling of the brick is usually done with a two-section 800 lb. roller, about 24 in. in diameter and about 30 in. long. One man can readily operate the roller.

Just before the grouting begins the surface of the brick is sprinkled with water to avoid absorption from the grout. The grout filler consists of a 1 to 1 mix of cement and sand, the sand not containing more than 3 per cent by weight of organic matter and clay combined, nor more than ½ of 1 per cent of organic matter. The sand should be rather uniformly graded from the finest to the coarsest particles, and it should all be such size as to pass through a 1/16th in. square mesh sieve. Not more than 30 per cent by volume, however, should pass a sieve having 50 mesher to the inch.

Seventh American Good Roads Congress.—The directors of the American Road Builders' Ass'n have decided to hold the next annual convention of the Association and the National Good Roads Show in Mechanics' Hall, Boston, Mass., during the week beginning Feb. 5, 1917. This will be the 7th American Good Roads Congress.

Current Engineering Practice Briefly Recorded

CONSTRUCTION VIEWS OF CONCRETE TEST ROAD CONSTRUCTION, PHILADELPHIA, PA.

The four illustrations presented here are from photographs taken during construction on the Oxford Pike service test road built in 1914-15 by the Philadelphia Bureau of Highways, Mr. W. H. Connell, chief. This road was fully described in our issue of April 26 and unusually complete detail costs were given. It was a concrete road with bituminous surfacings of various kinds. Figure 1 shows the concrete mixer in operation and brings out one feature of interest. This is the use of portable sections of track on which to run the mixer. Each section, as will be seen, is a complete unit, consisting of rails and cross ties assembled and fastened in one piece. Figure 2 shows the finishing operations. The screed was operated by two men using the metal side forms for guides. The finishing bridge from which the floating was done is clearly shown. Figure 3 shows the earth covering of the concrete slab; placing and removing this covering cost from 7 to 10 ct. per square yard. Figure 4 shows a stretch of completed road.

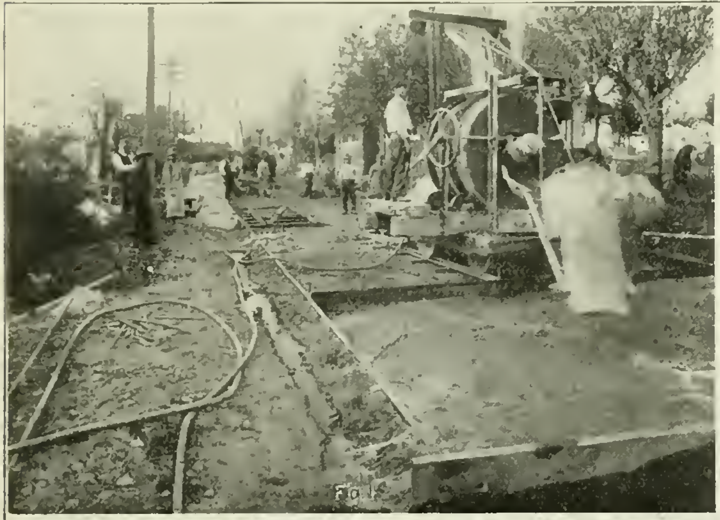


Fig.1

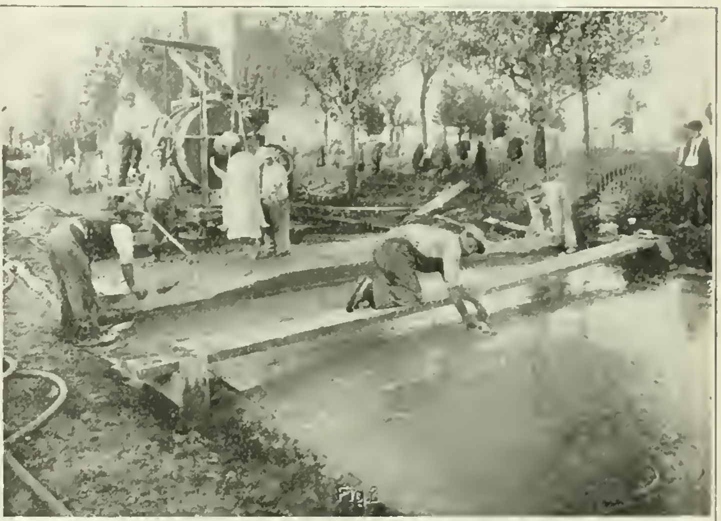


Fig.2

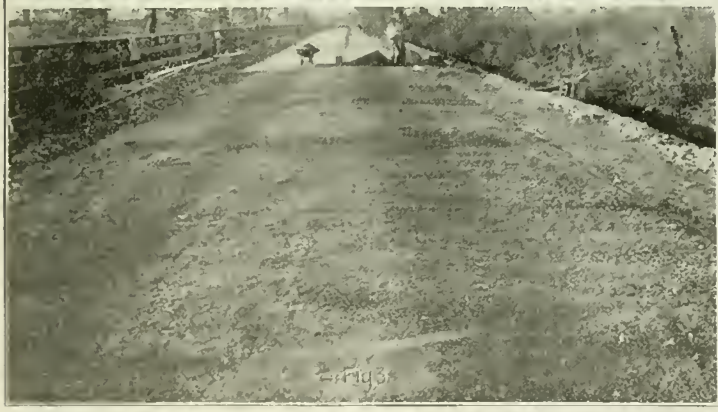


Fig.3

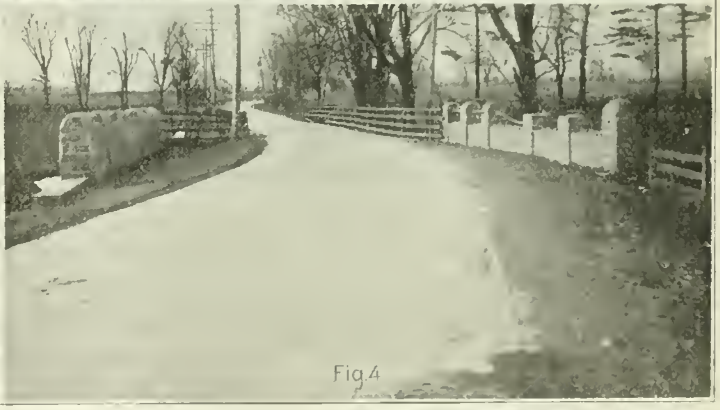


Fig.4

THE BONUS SYSTEM IN TRUCKING FREIGHT INTO RAILWAY CARS.

A steel plate trucking surface, together with a bonus system of payment, has increased output at Silvis Transfer, Illinois, on the Chicago, Rock Island & Pacific Ry., says the Railroad Age-Gazette. Following the installation of the steel trucking surface, a larger truck was installed with 12-in. wheels 3 in. wide, carrying a frame 27 in. wide and 5 ft. 9 in. long, with a 7-in. nose and with handles bent to an 80-deg. curve. Racks were also provided for these trucks, which, with a few 4-wheel Reynolds trucks, a dozen 6-wheel dollies and a few long-arm levers and pinch bars, comprise the equipment used at this point.

The men originally worked in crews consisting of one check clerk, one caller and five truckers. The number of truckers was reduced to four and after the installation of the steel runways and the large hand trucks to three. On May 1, 1914, 100 additional 2-wheel hand trucks were secured, after which a modified drop truck system was installed whereby the truckers were kept out of the cars which were being loaded and the number of truckers in each gang was reduced to two. At the same time the truckers' rate per ton was reduced from 16.01 ct. to 10.66 ct., but by removing the necessity for the men to enter the cars the two men handled about the same tonnage previously handled by three. This change, however, required some addition to the stevedore force.

In September, 1912, the gangs were placed under the bonus system, their former wage being guaranteed. Some of the crews earned a good bonus from the start, while others preferred to depend on the guarantee, and in some instances did not do as much work as formerly. On Jan. 1, 1914, the guarantee was discontinued, since which time every crew has earned considerably more than its old rate, while the freight has been handled at a reduced cost per ton.

MAGNETIC IRON CORNER MONUMENTS.

Magnetic iron monuments are recommended by N. Y. Taylor, Minnesota Surveyors' and Engineers' Society, who says: I have set now over 500—of different kinds of metal corners from ½-in. rod 20 in. long to 2½-in. square 36 in. long—and find that they are all more or less magnetic, according to the quantity and kind of metal used. After you have completed a survey, mark your initial corners with magnetic iron monuments of not less than 1 in. in diameter and 36 in. long; drive the monuments with a hammer, making light strokes, thus adding to its magnetism by this tapping process. It is entirely possible to find this corner when needed by the aid of a small needle compass, and not antagonize the traveling public by breaking up several square yards of gravel road or cement walk. In village surveys I have found it very practicable to set my iron monuments at the intersection of the center lines of the outside streets, two monuments in each street. Litchfield, Minn., was marked in this way about 1879—about 40 monuments set—and we never have any trouble in street or lot surveys.

STEAM SHOVEL EXCAVATION IN SHALLOW CUT FOR ROAD WORK.

A road grading cut 1.6 miles long and nowhere exceeding 18 in. in depth was made Oct. 1 to Dec. 10, 1915, or in 54 days, for a brick on concrete base pavement on Ocean Ave., Deal, N. J. The total amount of excavation was 30,000 cu. yd., and the shovel used was a Bucyrus with ⅝-cu. yd. dippers, and between the dates named it excavated 17,704 cu. yd. Working a 10-hour day, the greatest yardage was 477 cu. yd.; the average yardage, excluding lost time, was 33 cu. yd. per hour. During the 54 working days 25½ hours were lost, due to rain or other causes. Some partial records were as follows: In 9 days two blocks 700 ft. long and 50 ft. wide were cleaned up. Again, in one week, in a cut running from 9 to 18 in. deep, an advance of 200 ft. per day was registered, or an average of about 350 cu. yd. per day. The haul averaged about a half mile, which made it necessary for the shovel to wait for wagons at times from two to three minutes. The illustration, loaned us by the Excavating Engineer, shows the shovel at work and equipped with a canvas front to protect the operators from the cold winds. The contractors were: The Shreffler-Burns Co., Newark, N. J.

COSTS OF WELL DRILLING IN ORE PROSPECTING IN ARIZONA.

The drills used were Armstrong No. 22, except that in place of the usual engine and traction attachments an electric motor was substituted. The electrical equipment, as described by Wm. R. Grunow in Engineering and Mining Journal, consisted of a 25-h.p. motor, controller, circuit breaker, and resistances mounted on the drill frame. Work was begun in June, 1914, and to June 1, 1915, with four machines 51 holes aggregating 37,025 lin. ft. were drilled. The deepest hole was 1,039 ft.; 11 holes went to depths ranging from 800 to 842 ft.; 13 averaged between 730 and 799 ft.; 12 from 700 to 740; and the rest were with a few exceptions put down to depths ranging from 500 to 700 ft. The average depth of all the holes on June 1, 1915, was 726 ft. The total number of shifts during which work was being done at the rigs was 2,248.7, from which the general figure of 44.1 working shifts for 726-ft. hole may be derived. In connection with this, however, it must be borne in mind that on moving and casing jobs the day and night shifts worked together, and that this is counted as one shift. On this basis the average feet per shift for the entire period was very nearly 16.5. The record advance for one shift was 78 ft., but this was done while spudding. Footages varying from 50 to 77 for one shift were of common occurrence.

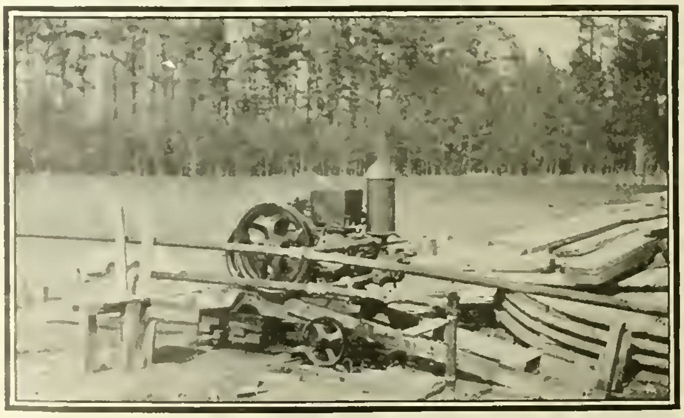
Allowing 240 paid shifts per month to the four rigs under normal running conditions, 2,248.7 shifts represent 9.37 months during which all the machines were in actual operation. From this it follows that the average footage per working month made by each rig for the year was 988 ft. The total number of actual drilling hours for the year was 9,772.5, giving an average of 3.79 ft. per hour.

The following summary shows the performance of each of the machines during the year ending June 1, 1915:

Drill No.	No. of holes.	Total footage.	Drill shifts.	Ft. per shift.	Total cost.	Cost per ft.
1..........	13	9,814	626.09	15.68	$18,443.75	$1.879
2..........	14	10,781	654.97	16.46	19,764.86	1.833
3..........	13	8,628	478.82	18.02	14,271.10	1.654
4..........	11	7,802	488.82	15.96	13,208.67	1.693
Total	51	37,025	2,248.70	16.46	$65,688.38	$1.774
Stations and roads					171.47	
Casing					2,617.98	
Cables					7,382.21	
Total					$75,860.04	$2.048

WATER SUPPLY FROM WELLS FOR CONCRETE ROAD CONSTRUCTION.

Water consumption for concrete road construction varies from 100 to 250 gal. per cubic yard of concrete in pavement. Sources of supply, besides muncipal water works, are streams and pools along the road route and, less frequently, existing or specially driven wells. On the Coleman Du Pont concrete road in Delaware especially driven wells were employed in most instances. The southern part of Delaware is very flat and consequently the water level is high, except in extremely dry weather. The water level varies from 5 ft. below the surface to 25 ft. below the surface, with the best flows at about 25 ft. below the surface. Water at this level could be counted upon even in the driest period. The test wells were sunk to a depth of 80 ft. A small flow of water was obtained at 5 ft., a satisfactory flow at 25 ft. and a small flow at about 70 ft. The economical depth was 25 ft. If water was not obtained at this depth, it was found to be economical to drive the well at some different location. In most cases 1¼-in. pipe was used and two wells were driven side by side about 5 ft. apart. These were connected to a gasoline pump. The water was delivered in a pipe line running parallel with the construction. In some instances this pipe line was 1½ in. and in some instances it was 2½ in. The large size pipe was far more satisfactory and a great deal better work was obtained from this larger size pipe. Some of the lines were equipped with a safety valve and adjusted to release at the proper pressure. It was found to be necessary to have this valve near the mixer and not near the pump. A very satisfactory way to obtain the pressure, was at the end of the pipe line to erect a pipe approximately 40



ft. long, with the end open, thus, allowing the water to flow from this 40-ft. pipe. In this way nearly constant pressure was obtained, except for the fluctuations in the line caused by the pump.

The cost of these wells was between $15 and $20, each. Charles Upham is Chief Engineer of the Coleman Du Pont road.

COST OF CONCRETE FENCE POSTS.

The C. B. & Q. Ry., according to the Railway Age Gazette, has been manufacturing reinforced concrete fence posts for several years at Havelock, Neb., at a cost of 21 ct. each, using a plant that cost about $6,500. The plant is housed in a frame building, 28x175 ft., steam heated so that work can be conducted in cold weather. The average output has been 100,000 posts annually. The capacity is 10,400 posts per month of 26 days of 10 hr., with a National concrete post machine and a working force of 12 men. The washed sand and gravel mixture is stored in an 800-ton bin, which is filled with a clamshell bucket. A 1 to 4 mixture is used, and for 100 posts there are required 19.8 sacks of cement and 2.3 cu. yd. of sand. There are six wires in each post for reinforcement. Posts are 7 ft. long, circular in section, 3½-in. top and 4½-in. butt. There are 13 pin holes in each post.

COST OF CONCRETE ROAD IN BLAIRSVILLE TOWNSHIP, ILLINOIS.

The road was built in the fall of 1915, construction operations lasting from Oct. 1 to Nov. 27. The concrete pavement was 10 ft. wide and 3,355 ft. long, and was 3,720 sq. yd. in area. Expansion joints were spaced 100 ft. Materials at railway siding cost as follows: Cement, $1.29 per barrel; sand, per cubic yard, $1.35; stone, per cubic yard, $1.35. The average haul was 0.52 mile and teams cost 40 ct. per hour. Wage of labor was 22½ ct. per hour. The amount of cement used per square yard of pavement was 0.29 bbl. The costs given do not include contractor's profit and overhead charges, and engineering and general supervision were donated by the State Highway Department:

COST OF LABOR AND SUPPLIES.

	Cost per sq. yd.
Engineering and general supervision	[1]....
Superintendence and inspection	$0.063
Insurance	.012
Excavation	.226
Stone, 546 cu. yd. at $1.35 f. o. b. siding	.198
Unloading to storage or loading sand and stone direct	.038
Hauling stone or gravel	.075
Sand, 323 cu. yd. at $1.35 f. o. b. siding	.117
Hauling sand	.044
Cement, 1,080 bbl. at $1.29	.375
Hauling cement	.024
Incidental hauling	.003
Clearing right of way	....
Shaping and rolling subgrade and side roads	.214
Mixing and placing concrete handling forms and joints	.180
Covering, seasoning and cleaning concrete	.025
Cost of culverts and bridges	.006
Freight on equipment and unloading same	.037
Depreciation or rental on equipment	.028
Total cost	$1.665
Cost, excluding excavation, culverts and bridges	1.433

[1] Indicates paid by the State Highway Department.

METHOD OF SETTING GAGE BOARDS FOR DETERMINING WEIGHT OF STONE IN VESSELS.

The stone is passed over scales and placed on board the vessel, readings of displacement being taken fore and aft for successive loadings. At the beginning and at the end the load intervals for recording drafts are taken smaller than near the middle in order to establish the curve better at points of more sudden change. Intervals of from 20 to 25 tons, evenly distributed in the hold of the vessel, are usually taken at the start, which may be increased to 50, 75 and 100 tons as the loading proceeds, the intervals being again reduced near the completion of the loading, although the curve at the upper end does not change as fast as at the lower end. The displacement is usually read on two gages, which are vertical glasses set against broad boards located with reference to some immovable and unchangeable points on posts over the keel of the vessel near the bow and the stern. The glasses, or boards, are calibrated to even tons from the results of notes taken at the "weighing-in," by making a plat of recorded drafts to form a displacement curve from which interpolated values are placed on a gage board drawing for record, after which they are scribed on the gage board itself. This procedure, discribed by A. S. Ackerman, was used in the Cape Cod Canal breakwater work.

DEFINITION OF KNOTS IN WOOD BY THE AMERICAN SOCIETY FOR TESTING MATERIALS.

Knots in timber are classified as round and spike in form, and as sound, encased, loose and unsound in quality.

A round knot is either oval or circular.

A spike knot is one sawn in a lengthwise direction; the mean or average width being considered in measuring these knots.

A sound knot is solid across its face, and as hard as the wood surrounding it; it may be either red or black, and is so fixed by growth or position that it will retain its place in the piece of timber.

An encased knot is one whose growth rings are not inter-grown and homogeneous with the growth rings of the piece it is in. The encasement may be partial or complete; if inter-grown partially or fixed by growth or position that it will retain its place in the piece, it is considered a sound knot; if completely inter-grown on one face, it is a water-tight knot.

A loose knot is one not firmly held in place by growth or position.

An unsound knot is one not as hard as the wood surrounding it, or one having a hole in it.

DEFORMATION OF CONCRETE UNDER LOADING.*

Concrete under loading is subject to slow but continuous deformation. This has been demonstrated by McMillan.[1] It seems likely that this gradual yielding or sagging under load, which McMillan compares to the yield of ductile metals, is more closely analogous to the deformation of rock. Part of it may be explained by the fact that cement is soft and slightly plastic material, which is kept plastic by the amount of water absorbed by the colloidal, hydrated constituents. Part of the deformation may be permitted by the progressive destruction and reformation of an unstable, amorphous hydrate. Some of the amorphous hydrate almost surely crystallizes in time, and the slow hydration of $2CaO.SiO_2$ must go on long after all the tri-calcic silicate and aluminate have become hydrated; thus, crystallization and fresh hydration of material provide the continuous formation of a bond. Probably there are small, local ruptures within the concrete member, which are filled by the hydration of the di-calcic silicate, or by the squeezing in of plastic amorphous hydrates. Further, the hydrate of the tri-calcic aluminate is soluble, and it is likely to be transferred in solution to even tiny openings, and to be deposited there. Thus, openings or cracks formed by local failure are not sure to remain unfilled in the presence of a cement of the physical and chemical character of hydrated Portland cement. The means of this healing of cracks and filling of openings in concrete would be detectable under the microscope, if it were possible to tell the products of hydration of the different silicates and aluminates from one another. Unfortunately they are all non-crystalline, amorphous, white materials, which are optically indistinguishable one from another. It is certain that some cracks formed in the early stages of a progressive loading later disappear.[2] The important point is that deformation of a concrete member which has been effected very slowly does not prove necessarily that there is a serious diminution in the strength of the cementing bond, although there is likely to be serious alteration in reinforced members.

---

*From "Rock Studies Applied to Concrete," by T. T. Quirke, Civil Engineers' Society of St. Paul.

[1] Franklin R. McMillan, Univ. of Minn., Studies in Eng. No. 3, 1915.

[2] Duff A. Abrams, Proc. Amer. Soc. Testing Materials, Vol. XIII, 1913, p. 916.

ROAD WORK IN IOWA.

According to a statement in the June Bulletin of the Iowa Highway Commission, the sum of $13,525,364 was expended in 1915 in roads and bridges in that state. Of this amount $6,629,252 went for bridges, $3,403,000 to the County road system and $3,171,000 to the township road system.

During 1915 there were 462.7 miles of road constructed to permanent grades at a cost of $618,138.00, or $1,336.00 per mile; 355.9 miles constructed to temporary grades at a cost of $242,868.00 or $682.00 per mile; 2,358.8 miles constructed to natural grades at a cost of $359,205.00, or $152.00 per mile; 182 miles were hard surfaced, and 15,400 miles were dragged an average of 29 times, at an average cost of $0.713 per mile one round trip. A comparison of the work accomplished during 1915 with that accomplished during 1914, is as follows:

	Miles. 1914.	Miles. 1915.
Built to permanent grade	418	462.7
Built to temporary grade	416	355.9
Tractor grading	1,210	2,358.8
Surfaced	75.6	182

The Bulletin states that due to the provision of the law requiring that road grading must be advertised, the price of such work has been forced down to an average of 18 ct., or 20 ct. per cubic yard, whereas formerly such work cost from 25 ct. to 50 ct. per cubic yard.

WIDENING OF 12TH ST., CHICAGO, TO BE STARTED SOON.

The last legal obstacle to the widening of 12th St. at Chicago, Ill., as far as the lower courts are concerned, was removed last week by a decision handed down in the Superior Court. It is now possible that actual construction on this $8,000,000 project will be started this summer. Under the improvement 12th St. will be widened to 100 ft. from Ashland Ave. to Canal St., and to 118 ft. from Canal St. to Michigan Ave. The cost, including awards to property owners, the building of bridges and viaducts and other expenses will be about $5,000,000. An additional $3,000,000 will be expended for rehabilitation, including the laying of new pavements, sidewalks, street lamps, etc. The work will be carried out under the direction of the Board of Local Improvements, of which Michael J. Flaherty is President.

A 265,000 Acre Drainage Project.—Plans for one of the largest drainage districts in Florida are now before the U. S. War Department and are awaiting approval, this being a necessary preliminary to construction. This project—the Upper St. John's District—includes approximately 265,000 acres of land along the valley of the Upper St. Johns River, and extends from a point west of Cocoa south to Fellsmere. The estimated cost of the contemplated improvements is in the neighborhood of $2,500,000. Isham Randolph & Co., Jacksonville, Fla., and Chicago, Ill., is Chief Engineer of the District.

Extension of Forest Preserves in New York.—The citizens of the State of New York will vote this fall on the question of a bond issue of $10,000,000 for the extension of the forest preserve and the Palisades Interstate Park. If the bond issue is approved $7,500,000 will be available for the purchase of land for the Adirondack and Catskill Parks and $2,500,000 for the enlargement of the Palisades Interstate Park.

PERSONALS.

W. A. Browning has been appointed city engineer of Highland Park, a suburb of Dallas, Texas.

C. A. Cunningham has been appointed manager of the municipal water and light plant of Tucumcari, New Mexico.

Leeds & Barnard, consulting engineers, Los Angeles, Cal., have removed their offices to the Central building, that city.

Dewitt A. Bandeen has been assigned by the New York City Bureau of Municipal Research to study new forms of government with Ray S. Blinn, city manager, of Westerville, Ohio. Mr. Bandeen is a graduate of Otterbein University, and also studied in John Hopkins University. He has a fellowship with the Bureau which pays his expenses.

The degree of doctor of science has been conferred upon Samuel Rea, president of the Pennsylvania Railroad, by Princeton University.

Messrs. M. C. Walker, W. F. Callahan and Ed. F. Leary have organized the Callahan-Walker Construction Co., with offices at Omaha, Nebr.

W. B. Elliott has been reappointed engineer of the Water Users' Association of Phoenix, Ariz., and his salary increased from $2,700 to $4,000 per year.

Samuel Murray, for some time past acting chief engineer for the Oregon, Washington Railroad & Navigation Co., has been appointed chief engineer.

J. E. Van Liew, chief engineer of the Des Moines Bridge & Iron Works since 1913, has resigned from that company and has organized the Des Moines Steel Co., Des Moines, Iowa, to engage in the fabrication of structural steel.

Waldemar Lindgren, professor of theology, Massachusetts Institute of Technology, has had the degree of doctor of science conferred upon him by Princeton University.

F. H. Nicholson has been appointed assistant engineer of the New York, New Haven & Hartford R. R., and will have direct charge of investigation of automatic train control.

G. J. Den Broek, C. E. W. Van Panhuys, F. L. Schlingemann, and J. C. Reiquersberg, engineers of the Holland government, are now in this country studying the New York barge canal.

John B. Yeon, roadmaster of Multnomah County, Oregon, has been presented with a solid silver plaque commemorating in a measure his services in the construction of the Columbia River Highway.

William Barclay Parsons, consulting engineer, New York City, has been appointed a member of the commission to investigate the project for the construction of a bridge over the Mohawk River at Schenectady.

R. O. Whiteaker, Assoc. M. Am. Soc. C. E., of Whiteaker & Washington, civil engineers, San Antonio, who is captain of Troop "C," First Texas Cavalry, in the Federal service, has been ordered to Laredo, Texas, with his command to guard the border.

A prize of $100, offered by the Barber Asphalt Paving Co., to students of highway engineering at Columbia University, has been awarded to Mortimer L. Neinken, of Brooklyn, for an exhaustive study on the "Comparison and Selection of Roads and Pavements."

W. E. Tretheway, president and general manager of the Stockton Iron Works, Stockton, Cal., has disposed of his stock in the corporation, and will retire from active business. He has designed much machinery used in dredging and excavating work in California.

E. H. Clement for the past four years district manager of the Fiske-Carter Co., with offices at Charlotte, N. C., and A. B. Schofield, Worcester, Mass., and W. A. Thomasson, Charlotte, N. C., have organized the E. H. Clement & Co., and will engage in the contracting business.

B. H. Klyce, for the past ten years engaged in municipal engineering, and Walter J. Kackley, a bridge and drainage engineer, have formed the firm of Klyce & Kackley, with offices in the Life & Casualty building, Nashville, Tenn., and in the Real Estate building, Miami, Fla. The firm will specialize in municipal, highway and drainage engineering.

Mr. Frederick W. Lindars, for several years connected with the Bureau of Municipal Research of New York, has been appointed by the Public Service Commission for the First District as Chief of Accounts, a new position, at $8,000 per year. Mr. Lindars' principal duty will be the establishment of an adequate system of accounting under the Dual System of rapid transit. This work is necessitated by the fact that several of the new lines under the Dual System will be placed in operation within the next year or so, and it is deemed advisable to establish within the Commission a system of accounting and checking of the operations of the two operating companies, namely, the Interborough Rapid Transit Company and the New York Municipal Railway Corporation.

NEW CATALOGS.

Aerial Tramways.—Paper; 6x9 in.; 64 pp. American Steel & Wire Co., New York.

Describes the Trenton-Bleichert system of aerial tramways. Illustrations are given of several interesting installations.

Well Drilling Machinery and Gasoline Engines.—Paper; 7¾x10½ in.; 128 pp. Armstrong Mfg. Co., Waterloo, Ia.

Illustrates and describes the well drilling machinery, tools, supplies, gasoline engines and steam power equipment made by this company.

Concrete Mixers.—Paper; 8x10½ in.; 24 pp. Waterloo Cement Machinery Corp., Waterloo, Ia.

New model Wonder mixers, models 15, 17 and 20, are described in this catalog. Specifications are given and details of construction are illustrated and described. These mixers are furnished with the folding track loader.

Expanded Metal.—Paper; 6x9 in.; 16 pp. North Western Expanded Metal Co., Chicago, Ill.

This is the June number of "Expanded Metal Construction," a monthly publication of the North Western Expanded Metal Co. It contains illustrations of a number of important buildings recently completed at Rochester, N. Y. Information on the use of expanded metal in building construction also is given.

Gates or Valves.—Paper; 6x9 in.; 28 pp. C. W. Hunt Co., Inc., West New Brighton, N. Y.

Contains illustrations and descriptions of the Hunt Co.'s standard types of gates or valves for controlling the flow of bulk material. The dimensions are given of those more frequently used in power house and storage pocket design. The cuts showing the application of these valves are selected with the idea of assisting where there is any question as to the type best suited to the requirements.

INDUSTRIAL NOTES.

The Traylor Engineering & Manufacturing Co. has under way an increase of shop capacity, which when completed will nearly double its output. The additions include a new machine shop 75x500 feet, with a balcony 30x460 feet for small tools, etc.; a 110x112-foot addition to the plate shop, and a four-story warehouse 75x188 feet.

The Automobile Club of America has retained the J. G. White Management Corporation as general operating managers of the club, the various activities of which include the operation of the club house at 54th to 55th street, west of Broadway, New York City, garages, efficiency bureau, testing laboratories, machine shop, supply department which furnishes to members all repairs and supplies, bureau of tours, club publications and to act in an advisory capacity with the board of governors and standing committees.

Engineering and Contracting

H. P. Gillette, *President and Editor*

Volume XLV. CHICAGO, ILL., JUNE 28, 1916. Number 26.

ARBITRARY STANDARDS IN CONCRETE CONSTRUCTION.

Concrete construction more than perhaps any other has been the victim of arbitrary standards. As a result concrete construction is today a crude art compared with the perfection it might have and will have a decade hence. In the single matter of proportioning, practice exhibits a subservience to arbitrary standards that should be the shame of engineers. A 1:2:3 mixture for pavement, a 1:2:4 mixture for reinforced structures, a 1:3:5 mixture for mass concrete unreinforced and there one has about all that average practice affords of scientific adaptation of proportions to raw materials and to structural purpose. This condition does not exist because we lack all but a rule of thumb knowledge of scientific proportioning. It exists because of the congenital disinclination of the concrete designer and constructor to exercise his brain to develop the possibilities of his material.

This accusation is not fabricated. Recently an experienced road engineer proposed that pavement concrete should be proportioned by sieve analysis of the aggregates. Criticism of the proposal was prompt. Summed up it was: "We know that 1:2:3 is a proportion which ensures good concrete from almost any decent character of aggregates, so why bother to seek further refinement of proportions? It is not denied that a 1:2:4 mixture with one quality of aggregate may make just as strong, and dense and abrasion resisting a concrete as a 1:2:3 mixture with another quality of aggregate. The lean mixture may save a little cement, but cement is cheap and analyzing and controlling aggregates is troublesome. Why bother? The purchaser gets a good road and that is all he wants. If we approve departure from the arbitrary standard of 1:2:3 mixture someone may come along who will not use his liberty wisely and the taxpayers will get a poor road. Better leave well enough alone." Is this illustration exaggerated? Not one whit.

The arbitrary standard is the bane of concrete construction in America. This is not only true of proportions but of materials. We use one kind of cement when we might use several, as is done in Europe. Just now we are trying to set an arbitrary standard of time that a batch shall be revolved in a mixer. The mixer must turn, we say, 1½ minutes. The fact counts nothing that we have no reliable figures to indicate whether the best concrete is had by turning the batch one minute or two minutes or ten minutes. The fact that concrete mixers are not all alike in efficiency, that the best will mix a batch as properly in one minute as the poorest will mix it in three minutes, also counts nothing. The only way to tell a mule from a horse is to measure their ears with a foot rule.

ILLOGICAL METHODS OF RATING ENGINEERING ABILITY.

In the effort to provide some short-cut way of rating the suitability of applicants for engineering positions many illogical methods have been advocated and not a few have been put into effect. Most illusive of all, perhaps, is the idea that a man's total ability can be analyzed into several abilities, to each of which a certain percentage of the total is assignable. Thus it might be assumed that if a man were seeking a job as a structural draftsman he would be rated as perfectly fitted if he could answer correctly certain questions, perform certain work, within a specified time, produce satisfactory evidence of being extremely industrious, perfectly honest, temperate, courteous, precise, quick, amenable to orders, etc.

Since no man can be "perfect" as to every desirable quality, it has been proposed to assign a given number of perfect score points to each essential quality, the total number for all qualities being 100. But what is the common unit—the "point"—by which different qualities can be measured? To ask the question is almost sufficient to make apparent the impracticability of rating men in this manner. Certainly the ability to pass a given technical examination has no relation to a man's integrity.

Perceiving lack of a common measure for character and for skill, it has been proposed to set up "a double standard," and give to character a rating in no way related to the rating for technical skill. But further consideration will show the "double standard" to be almost, if not fully, as illogical as a "single standard," for the simple reason that character itself is a composite of elements having no common unit.

Suppose a group of young men were seeking positions on a league ball team, and the manager were to attempt to select the fittest by any combination of tests other than playing ball, is it likely that he would obtain the best material for his team? True he might eliminate wholly unsuitable applicants at once by tests other than playing games. Inability to throw a ball with strength and some degree of accuracy, chronic ill health, ascertained egoism that resists instruction and discipline—such failures to measure up to a few important standards, would undoubtedly eliminate the worst candidates, but there would still be left many for whom no test would suffice save actual ball playing for a considerable period of time.

If, then, the best men even for a game of skill are not to be chosen finally in any satisfactory way other than by records established in playing the game, is it not more futile to seek to select men for positions requiring mental ability by applying any single, double or triple standard test?

Examinations and all short-cut tests of mental fitness are useful only as means of eliminating the wholly unfit and, unless the examinations and tests are very carefully considered, they may eliminate some of the most fit. Short tests of all kinds fail to disclose the capacity for mental growth, and tests fail also to bring out the mental marathon ability of a man. Ability to grow and ability at sticking to a problem are two of the most important faculties. Where do we find these rated in any schedule of tests? And who can rate them at all save by long observation?

There has been a deal of piffle published about the science of management, but perhaps the pifflest has been the "psychological tests" to which applicants for positions are to be subjected. A real knowledge of psychology makes for a wholesome respect for the almost inscrutible complexity of the mind, and tends, therefore, to dissuade from attempts to rate mental ability of a high order by any tests save those in which the final resultant becomes the criterion of mental value. When Edison sought to make a talking machine, the real test of his fitness for that self-selected position was the diaphragm, needle and revolving tinfoil—the combination that actually talked. When Childs went into the restuarant business, the test of his fitness was his ability to maintain a growing profit. What examination or brief test could have shown the successful fibre of young Edison or young Childs?

One of the common mistakes of would-be teachers of management is the supposition that the best managers have some mystic insight into human nature by virtue of which they cull the mental wheat from the chaff at a glance. But conversation with successful leaders dissipates such illusions. They, too, are fooled by appearances and brief tests, as we all are. But they don't stay fooled, and when they are satisfied that their assistants lack either capacity or desire to grow, changes are made that other assistants may be given a chance. In every live business organization there is never a static condition for any considerable time.

Experiments are constantly under way, both as to men and methods. Mistakes are being made and rectified. And so it must always be under every progressing manager. Action rather than intuition is the outstanding characteristic of the ablest managers. Their staffs are selected by no rating schemes other than the rating that is secured by actual trial.

THE POLITICAL OUTLOOK.

Engineers and contractors are particularly concerned in the political outlook because of its bearing upon the amount and kind of construction work. For several years new railway construction has been conspicuous by its meagerness. Now, however, the railways are experiencing a greater income than ever before. It was a billion dollars gross for the year ending June 30. If prevention of strikes and of unreasonable increases in wages and a sane Federal regulatory policy were assured, it can not be doubted that a new era of railway construction and betterments would soon begin.

Aside from the tariff, this is the greatest political issue before the American people, yet neither the Republican nor Democratic platform shows the slightest recognition of this salient fact. With a prospective railway strike of unprecedented proportions facing the country, neither of the great parties had the courage or foresight to declare in favor of Federal—as against state—regulation of railway rates and the wages of railway employes. We include wages, for it is now clear to students of the subject that wages are inextricably a part of the great problem of public regulation of railway transportation.

Fortunately, political parties in legislative action are usually more sane than their platforms, so that there is strong probability that the next Congress will enact laws that will tend to give the investor in railway securities greater assurance. This, it seems to us, is now all that is needed to bring about a revival of railway building, for it is absurdly short-sighted to assume that the country needs no great addition to its transportation systems.

The tariff will unquestionably be revised if the Republicans gain control next fall, and, even if they do not, the Democrats have announced belief in the desirability of a non-partisan tariff commission to study the problems that will arise when the great war ends. A protective tariff of some sort is practically assured, for nearly all politicians realize the disastrous situation that was imminent two years ago, the war alone being responsible for the subsequent manufacturing prosperity.

The states that have been most active in drastic regulation of the rates of public utilities have at last begun to show signs of moderation. Perhaps it is too soon to say that the menace of ignorant rate regulation is past, but at least it may be said to be passing. Damnation of utility corporations no longer suffices the local politician as a vote-winning shibboleth.

The great "efficiency movement," originated and promulgated mainly by engineers, has had a startlingly rapid success in municipal government regeneration. But a vast deal yet remains to be accomplished, and most of the ultimate accomplishment must be initiated by engineers. The engineer in politics is perhaps the most significant and promising occurrence of all recent happenings in municipal matters.

We confess to great optimism on the political outlook for the immediate future, and particularly on the outlook for the later year. The public is coming to realize that suitable executives can not ordinarily be secured either by popular election or by conventions. This is a forward step. New methods of selection of public executives, based on efficiency tests and records—not on mere examinations of the civil service sort—will come into vogue. And with their advent the executive engineer will find an attractive field for the exercise of his talents for the public good.

SALARIED EDITORS FOR ENGINEERING SOCIETIES.

Nearly every engineering society is in some degree a publisher. Even the very small society prints once a year a report of its business affairs and the technical papers and discussions presented at its meetings. Larger societies having a greater volume of business and of technical papers and discussions publish quarterly or monthly journals. For all of these publications advertising patrons and in a measure subscribers are sought. Editorial service is therefore required in the functioning of all engineering societies which publish their proceedings. The extent of this service is very small in the case of small local societies but for the large societies publishing quarterly, bi-montly or monthly "proceedings" or "journals," it often approaches that demanded by commercial engineering journals of considerable size. In practically all societies the secretary is depended upon for this service. If the society is one of the largest, clerical help and assistants perhaps relieve the secretary of most of the desk editing and other routine of editor's work, but his is the editorial management, supervision and decisions in all larger matters. An official editor, a responsible chief having power to initiate and direct society publishing and publicity work, is not possessed by any engineering society.

The preceding statement has been suggested by the action at its recent meeting of the American Water Works Association toward the employment of an editor for the association's publications. The action is a logical one. It could well be taken by a number of engineering societies of equal and greater membership. A properly qualified editor could greatly improve the publication work of any of these societies. He could also do for them that which very few of them are now doing—adequate publicity work for engineering.

THE HIGH PRICE OF EXPLOSIVES.

According to the Anthracite Bureau of Information in Wilkesbarre, explosives and their constituents have risen in price since last September as follows:

	Per cent.
Dynamite	80 to 120
Black powder	23
"Permissible explosives"	35
Dynamite caps	200
Sulphuric acid	500
Nitric acid	150
Glycerin	300
Nitrate of ammonia	150
Nitrate of soda	20
Saltpetre	250

Glycerin, one of the bases of dynamite, is no longer imported from Europe, and so large a part of the American product is being exported that manufacturers of dynamite are said to be experimenting with new high power substitutes for dynamite.

Contractors for rock work will be wise not only to secure the latest quotations on explosives before they bid, but, if possible, to make tentative contracts for explosives wherever their prospective work is extensive.

There is not a very bright prospect that the war will end this year. So long as it continues it is obvious that explosives will command an abnormally high price.

Black powder has risen much less in price than dynamite. This suggests the advisability of considering the use of black powder under conditions that would not have made it advisable a year or so ago.

In this connection we may again mention the use of larger drill holes and of "chamber blasting" as effective devices for reducing the unit cost of explosives. One of the reasons why black powder has been so largely displaced by dynamite has been the higher cost of drilling and "springing" holes large enough to hold an adequate amount of black powder. But the use of cable drills and of very large piston drills mounted on trucks has made it possible to drill very large vertical holes, at a comparatively low cost, in nearly all sedimentary rocks—limestones, shales and sandstones.

In the eastern part of America large "chamber blasts" have been less frequently used than in the West. Chamber blasts are made by charging small tunnels, often so small as to be called "gopher holes" or "coyote holes," with explosives. Black powder and Judson powder have been used very effectively in chamber blasting.

EDITORIAL PARAGRAPHS.

The blue print has become so much a commonplace in the work of the engineer that it requires effort to remember that its wide use dates back only 35 years. According to Professor Higbee of the University of Iowa, who has been delving into the history of mechanical drawing, the blue print process was perfected in 1880, though discovered in 1840.

The water works of York, Pa., date from 1816. In an entertaining little history of the works, recently published, we find record of laying a main across Codorus Creek "on the bottom" in 1850. Records of laying subaqueous pipe lines have since become familiar, but at that time the committee in charge of work considered that it had done something deserving of uncommon notice and its report contained the following pean of thanksgiving:

> The great, the perplexing difficulty—the doubtful operation—the tremendous undertaking with all its fearful threatenings is overcome, the bold enterprise is accomplished. The accomplishment of this great work, at the moment it was accomplished, presents a coincident which may well be regarded as a subject of wonder and admiration in all time to come—for, be it remembered that on the 4th of July at 12 o'clock M. precisely three-quarters of a century after the Declaration of Independence of these United States, this great work was completed, and closed by three hearty cheers by the brave and unflinching workmen, who enacted the work.

An inventor is wanted who will devise a satisfactory screen to prevent trout from getting into irrigation ditches. The Forest Service says it will be obliged to stop stocking streams with trout unless some means is had to prevent them from getting into irrigation ditches and being floated out into the alfalfa. It admits that fish make good fertilizer, but thinks that trout are too expensive for that purpose.

Much optimism was displayed by the steel manufacturers at their recent meeting. They predicted that higher prices and full operation would continue throughout the year. Users of their products will find small comfort from this prediction, and many of them undoubtedly will hesitate to capitalize war prices for structural steel in buildings and other structures.

A well known consulting engineer was quizzing a civil engineer near-graduate applicant for a position. The word pacificist came up. Asked to define verbally the word the applicant promptly announced that "it referred to a type of people living along the Pacific Coast." Lincoln, Nebraska, papers please copy.

Bids were opened June 15 by the State Highway Commission of Ohio for 39 road contracts covering 120 miles of highway. The estimated cost was over $1,300,000. With this letting 158 contracts have come up for bids so far this season. These provide for the construction of some 372 miles of state aid road.

MEASURING FLOWING WATER.

To the Editors: The writer was much interested in several articles in your issue of June 14, including reprint of a paper by Mr. C. O. Wisler, read before the Michigan Engineering Society, "Practical Methods of Measuring Flowing Water," also "Chemical Method of Gaging Stream Flow" and "The Article Which Reviews and Summarizes Practice." Material of this character is of value to practicing engineers, and your paper deserves credit for its frequent good service in this line.

Concerning the measurement of water, the writer has had experience with all the methods described. Nothing need be said about the value of weirs in measuring flows; when applicable and properly used the results are reliable. Velocity measurements by means of floats, especially surface floats, are extremely misleading, except in the hands of the most experienced observers; otherwise it is not unusual to obtain errors which over-estimate the flow by as much as 100 per cent. In fact, most methods have this tendency toward plus errors. The chemical methods, for instance where the titrations are accurately made, must necessarily over-estimate the flow, especially in large rivers, because a material amount of the solution does not get to the point of observation, being taken up by gradually increasing the amount of solution in the water above the point of observation, so that the observer would find less chemical than has been applied, which would make the apparent flow greater than actually existing.

The writer's experience with current meters has been with the Price instrument; where a stream is turbulent the meter will obtain successive impulses which are greater than the average, and the velocities of rotation will be retained, which tends to keep the velocity higher than the average. This can be largely overcome by having the rotating parts very light and possibly by the use a flywheel encased so as not to be actuated by the moving water. In one case where two Price meters were used—one very light and one heavy—they gave a very close agreement in a stream of uniform velocity, but under exactly the same conditions in a stream of violently varying velocity the heavier meter gave results 20 per cent higher than the light meter.

In a very variable flow pitot tubes have also a tendency to over-register, but for practical purposes, either pitot tube or the current meter is the most feasible apparatus for obtaining a very close approximation of the flow in large rivers; especially if the point of observation be selected where the river is as nearly uniform as possible in velocity. The writer's experience inclines him to the opinion that while the pitot tube is more accurate than the current meter, it is much more troublesome to apply on account of the difficulty of eliminating air leaks and air pockets. Yours truly,

J. W. Ledoux,

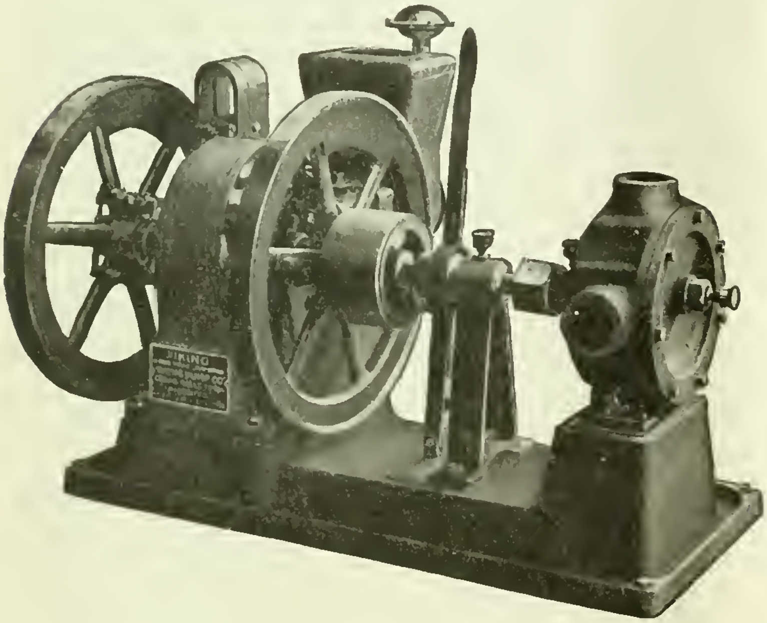
Chief Engineer, American Pipe & Construction Co.
Philadelphia, Pa., June 15, 1916.

APPROXIMATE PLANT EQUIPMENT FOR CONCRETE ROAD CONSTRUCTION.

The list of equipment required for concrete road construction is stated by W. A. McIntyre, Chief Highway Engineer, Portland Cement Association, to be approximately as follows: One 10-ton roller; half yard mixer; pump and gas engine; about 2,500 ft. of 2-in. w. i. pipe; 400 ft. of $^3/_4$-in. water hose; water barrels; one dozen wheelbarrows; three dozen shovels; three dozen picks; two 20-lb. crowbars; three rakes; two 50-lb. rammers; two steel trowels; two wooden floats; two sidewalk edgers; one level board; two templates; one bridge; 500 ft. steel channel forms with iron pins; 200 ft. of canvas 20 in. wide; 50 ft. of 2x10 planks for mixer. Such an equipment would cost about $6,000 and in addition it would be necessary to make provision for the hauling of materials.

A PUMP ESPECIALLY ADAPTED TO PUMP ROAD OILS.

The pumping unit shown assembled and in its essential parts by the accompanying illustration has shown in tests and practice exceptional efficiency in handling the heavy and viscous oils used in road construction. The assembled unit shown is self-contained and the motor is a gasoline engine, but electric motor driven and belt driven units are also provided where desired. The pump mechanism is the interesting feature. It consists of a head or casing with suction and discharge openings, of a rotating annular gear and of a rotating pinion. The annular gear fits closely inside the head and is keyed to the drive shaft of the motor. The pinion meshes with the annular gear and rotates on a stud shaft inside the casing. The intermeshing of the gear and pinion is tight at a point midway between ports so that the liquid sucked in and contained in the open spaces between the cogs of both wheels cannot follow the wheels beyond this point midway between ports and is forced out at the discharge port. As the wheels can revolve in either direction, either port can be used for suction. A report of a recent test of this pump by the makers follows:



Viking Pump for Heavy Liquids.

> The test was made on a 4-in. Viking pump back geared to a 15-HP. motor in the plant of the Barrett Co., at Cleveland. The test was made by pumping "flux oil," a very heavy and viscous material requiring a temperature degree of not less than 150 degrees before it becomes fluid enough to be handled readily. The pump delivered from the tank car to a large vertical storage tank. The result was that the 8,000 gal. of this material was exhausted in just 40 minutes, or at the rate of 200 gal. per minute, and required 14½ HP. by actual readings. There was a mistake made in the pipe installation on this particular unit, as they put in 3-in. piping, whereas it should have been not less than 4-in. The smaller pipe was the cause of excessive pipe friction. We would strongly recommend the use of a 3-in. Viking pump with a 4-in. piping and a 10 or 12½-HP. motor, and believe that this will give the same rate of delivery as above noted.

The pump is made in various sizes and mounted in various styles by the Schirmer-Frensdorf Co., Cleveland, Ohio.

A SUGGESTION FOR USING STREAM FLOW RECORDS OF THE U. S. GEOLOGICAL SURVEY.*

A mine of information on stream flows is contained in the reports of the U. S. Geological Survey on that subject, which have now attained nigh 400 unbound volumes, some of them quite bulky, making a burden on the resources of engineers who pay the rent of their own offices and shelf-room. It is no exaggeration to say that for water-power purposes, giving all data needed for that purpose, these 400 bulky reports could be condensed into 400 single-page cuts contained in one such volume, and at an enormous saving to the work, time and expenses of the hydraulic engineer.

For the purpose of facilitating comparison and reducing all the records to the same specific scale as it were, the collected diagrams should be plotted to represent second-feet per square mile, instead of second-feet. Underlying details would not be lost, but if ever needed (a matter of some doubt) could be supplied by the Survey Office. In answer to an inquiry requesting suggestions, the writer had the honor to make the above recommendations to the Geological Survey office and here reiterates this, his matured opinion on the subect.

If the daily discharges of a river at a certain point be plotted for the 365 days of the year, in the order of their magnitude (not consecutively in the order of the date of their occurrence, a perfectly smooth curve showing the year's discharge will be produced. Take fifteen or twenty such years, if the records avail, and three such curves may be produced; one of average flow, another enveloping all the minima flows, and a third enveloping the maxima flows. And for a period of that length the discharge of that river, at that point, has been portrayed practically for all time. Nothing, or little more, is needed in its hydrographic study, for the uses of a constructing engineer. Its original data may have interest for a meteorologist, when he philosophizes as to the relation between such three curves and rainfall data, but an engineer has nothing to do with that. The rainfall may be anything; it will not change the recorded run-off, nor the ranges of run-off shown by these three curves. And it is these data that are needed for useful purposes —the province of the engineer—in contradistinction to the pastures of recreation that invite the philosopher or scientist.

EXPERIMENTAL REINFORCED CONCRETE ROAD IN LOUISIANA.

During the summer of 1915 the State Highway Department of Louisiana of which W. E. Atkinson is state highway engineer in co-operation with the Parish of East Baton Rouge constructed an experimental section of reinforced concrete road. This is said to be the first rural road of this type built in Louisiana. The following description of the construction is taken from the recently issued report of the state highway engineer:

The pavement was laid for the highway extending north from the city limits of Baton Rouge and forming a section of the Baton Rouge-Clinton road. A length of 3,115 ft. was paved. The pavement section, as shown by the accompanying sketch, consisted of a 9-ft. concrete slab, with a thickness of 7¼ in. at the center and 6 in. at the sides, placed upon an earth subgrade. On each side of this slab sand-clay-gravel shoulders 3½ ft. wide were constructed and earth shoulders 4 ft. wide were then built from the gravel to the ditch edge, thus making a 24-ft. roadway with a 16-ft. surfaced center.

The concrete was reinforced with No. 26 American Triangular wire mesh placed 2 in. below the finished surface. Expansion joints were placed uniformly 30 ft. apart. They consisted of Kahn Electric Filler ½ in. thick placed between Anchorite expansion plates.

The concrete pavement and gravel shoulders were placed upon a well graded, drained and rolled earth foundation of sand-clay material. The subgrade was rolled and compacted with an 8-ton roller before the concrete was poured.

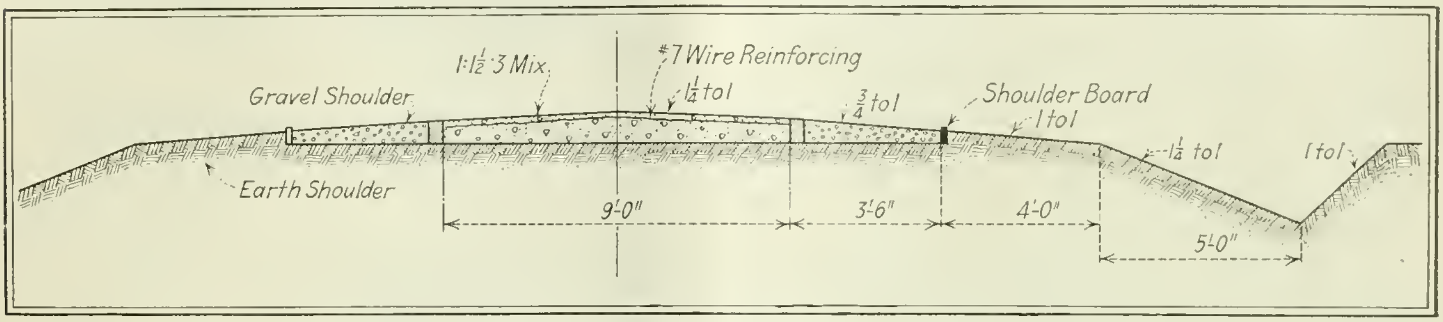
The concrete was a 1:1½:3 mix, coarse brand of Portland cement being used throughout. The aggregate consisted of Brookhaven sand and gravel. The mixing was done in a Chicago Batch type mixer having a capacity of 84 cu. yds. per day. The concrete, of a plastic consistency, was deposited through an extensive gravity chute into place between 2 in. by 6 in. form boards held in place with iron pins. A template was used for the initial floating and the surface finished with wooden hand floats.

---

*Clemens Herschel, in Journal, Boston Society of Civil Engineers, June, 1916.

After the concrete had obtained its initial set, earth retaining walls were constructed along the edge of the slab, with such cross levers as gradients of the road demanded. The reservoirs thus formed were then filled with water and the concrete kept submerged for a period of 16 days, until it had become thoroughly and uniformly seasoned and obtained its final set. It is stated that as a result an unusual degree of hardness and toughness was obtained and the slab presented a smooth and uniform surface which has shown few signs of chipping, even at the edges of the pavement.

In the construction of the last 600 ft. of the pavement, hydrated lime, mixed with the concrete to the extent of 10 per cent of the cement was used. This produced a more dense and homogenous mass and made the mixture more plastic and easier to work.



Cross Section of Experimental Reinforced Concrete Road in East Baton Rouge Parish.

Upon two sections of the pavement, each 400 ft. in length, two types of concrete hardeners were used. The detail consisted, in one instance, of the application to the finished surface before final set had taken place of "Agatax," a liquid preparation, and in the other instance of "Trus-Con Ironite Flooring." The use of these materials as well as of the hydrated lime was made for experimental purposes.

The cost of the concrete pavement only, including the preparation and rolling of subgrade for the slab and gravel shoulders, was $6,990 or $2.24 per sq. yd. The work was not carried out under ideal conditions and its cost is higher than it should otherwise have been. It is the opinion of the Highway Department that this type of concrete highway could be constructed under normal conditions at a cost not to exceed $1.40 per sq. yd.

GRAVEL ROADS CONSTRUCTED IN NORTHWESTERN MICHIGAN.*

The ideal gravel would be one which contained pebbles from hard and tough native rocks in sufficient number to give a minimum of voids. It should have filler of the kind and amount to give cementing qualities and fill all voids without impairing resistance to wear. The most desirable material should contain 70 per cent to 85 per cent of pebbles and a sand filler with only at most a trace of clay. A gravel which is screened too thoroughly and which consists almost entirely of very hard pebbles will be too slow in hardening unless a binder is added, particularly if the subgrade soil is sandy.

Where limestone pebbles are plentiful very good results have been secured with gravels testing as high as 95 per cent. A gravel containing a small amount of clay makes a highly desirable foundation course on sandy soil, but should not be used for wearing surface if it is possible to avoid it.

On a clayey soil a gravel containing a sand filler should be used whenever possible. Glacially deposited materials usually contain good fillers. In recently deposited river gravels the pebbles are usually worn very smooth and all soluble materials removed so that consolidation is very much retarded. When such a road does compact, however, it gives very good service.

The use of gravels containing any considerable amount of clay, particularly on clay soils, should be looked on with suspicion. Such materials consolidate very quickly and make an admirable road while weather conditions are favorable if properly handled. Unless particular pains are taken in spreading and in working when first put on, the road hardens with a wavy surface. When the weather is very dry the clay contracts, loosening the pebbles and offering sharp edges to the wear of vehicles. It soon pulverizes to fine dust and under heavy auto traffic is blown off the road, causing complaint from people residing along the road. During a rainy period it softens and loses binding power. The road becomes muddy and ruts quickly. Slight depressions hold water and the passing vehicles wash out the clay quickly, resulting in a very rough road.

A very satisfactory way to handle grading is to build a flat top section which is about the thickness of the metal below the grade shown on the plows. The grade thus built is then trenched out with a plow and road grader and trimmed by hand to form a curved trench to conform to the specified cross section. This can be accomplished by plowing out a furrow on each side and make a round trip with a road grader with the blade so tilted as to scrape the surface at the center and dig on the extreme edges. The earth thus thrown out forms the shoulder. The trench can then be trimmed by hand just ahead of the spreaders. If the soil is retentive side drains should be put in at intervals to take care of water which collects in the trench. These should be placed on with sides at all low points in the grade and close enough together to carry off water which might collect at other places in the trench.

The trench should be rolled ahead of the gravel with as heavy a roller as can be secured if the soil will compact under rolling. This develops weak spots and saves material when gravel is being put on. Where the soil is sandy, straw, marsh hay, cedar bark, sweet fern, fine mesh or similar material should be put under the gravel so as to prevent sand from mixing with the bottom course.

When the subgrade is prepared the best gravel which can be secured at a reasonable price should be placed about 6 in. thick. In spreading this course the first load should be dumped at the point nearest the source of supply and the next one hauled over it. In this way the compacting effect of the loaded wagons is secured and when the last load is dumped it will have been hauled over all the preceding ones. Twice daily the road should be gone over with a spike-tooth drag and the ruts should be kept filled by the use of a road drag. Whenever the gravel is wet it should be rolled with a horse roller. After this course has been thoroughly compacted the top course can be placed. No gravel should be used for the top of wearing course which does not test 75 per cent.

In some localities gravel is hauled during the winter. Larger loads can be hauled and farm teams can be secured more readily and at a lower cost than during the summer. Loads of 3 and even 4 yd. are not uncommon when the sleighing is good. Sometimes the gravel pit is so located as to be practically inaccessible during the summer months either on account of long hauls or because of hilly or sandy roads which must be used at the season of the year. During the winter a snow road can be laid out so as to avoid heavy grades. Temporary openings in fences or roads across cultivated fields are not objectionable in the winter. A better grade of gravel is secured as the over burden is frozen down to the gravel and can be broken down and hauled away in chunks without any danger of becoming mixed with the good material. Where winter hauling is contemplated the grade should be prepared during the summer and trenched the last thing before the fall freeze up. The trench should be cut about 2 ft. wider than the width of the road bed desired and the gravel should be spread about a foot narrower than the desired width. In the spring when the frost is out the gravel can be lined up and then the shoulder plowed to it. About 10 per cent more gravel must be put on to allow for waste in spreading and for filling ruts in trench. Dynamite must be used to open pits and blow off over hanging banks. Snow must be shovelled out of trench in order to place material in its proper place.

---

*From a paper by L. H. Neilsen, District Engineer, Michigan State Highway Department, presented at the Battle Creek Highway Convention.

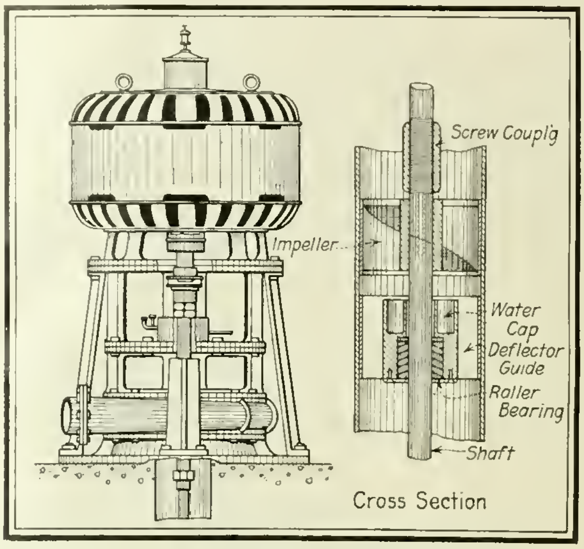
In the past the usual practice has been to place all the gravel in one thickness. There is nothing gained by placing two courses during the same winter as the hauling does not compact the frozen material even when the gravel is hauled on wagons. The great depth of loose gravel made is difficult to travel. In many places the gravel bed simply crusted over to the depth of 3 or 4 in. When subjected to heavy traffic it broke through. These breaks usually came during dry periods when the gravel did not recompact and cut through in to the subgrade. It was a difficult matter to spread uniformly during the winter and wavy surfaces often resulted. Because of the unsatisfactory results this practice has been very largely discontinued. The usual practice now is to place the bottom course one winter, work it down well the following spring and put on the top course on wagons during the summer or the following winter. This gives a thoroughly compacted foundation and the top course soon hardens under working and traffic.

No practical amount of continuous rolling will give to a gravel road the hard finish surface that can be secured in macadam surfacing. Gravel packs smooth and rounds and no mechanical bond can be expected, particularly if the gravel is dry as soon as a certain stage is reached. No further benefit compensates for the expensive rolling that can be expected. Sprinkling gravel during the dry weather is a hopeless task, as the pebbles cover such a large surface to such a depth that the water evaporates very soon and no great benefit is derived. This does not mean that a gravel road should be rolled as often as it is wet enough. After much heavy rain the road should be flooded in order to shape it and then rolled until it dries out. Traffic should be allowed to use the road at all times after the gravel is on. Persistent rolling at the proper times together with dragging, flooding and the effect of traffic will give a well shaped surface economical and in the shortest possible time.

The addition of binding material is in exceptional cases necessary, but should be avoided whenever possible as it more often results in a road surface with impractical wearing qualities, particularly if the binder is all clay in its nature. Stone dust is much more efficient than clay as a cementing agent even in extreme dry or wet weather.

A NEW PUMPING SYSTEM FOR DEEP WELLS.

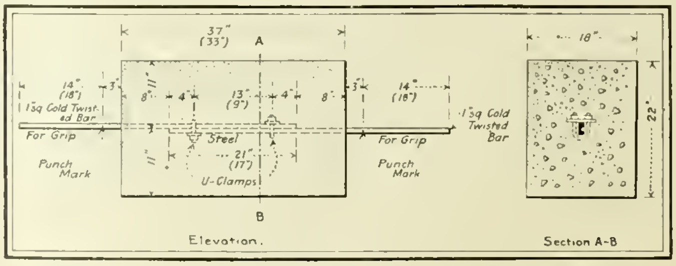
The illustration shows a pumping unit for deep wells which has been operated successfully for some years at Memphis, Tenn., and which has recently been patented by the inventor. As indicated, the unit consists of a motor-driven centrifugal pump on a vertical shaft that extends down the well and carries a series of screw impellers. Between each pair of impellers is a roller bearing for the shaft and guide vanes which arrest the whirling motion of the water set in rotation by the impellers. The shaft, impellers and guide vanes are inclosed in a tube. Tube and shaft are made up in 4-ft. sections joined by screw couplings, and are connected section after section and lowered into the well until the lowest section is below water level. Then to the top of the shaft is coupled to the centrifugal pump and motor shaft. At the Memphis installation, consisting of 15 units, the motors are constant speed induction, 100 hp. at 550 r.p.m. The centrifugal pumps have 28-in. impellers and deliver water at 60 lb. pressure. The system described is the invention of Wirt J. Wills, Memphis, Tenn. Mr. Wills is superintendent of the Memphis Water Works.



Wills Deep Well Pump.

STRENGTH OF CLAMPED SPLICES IN CONCRETE REINFORCEMENT BARS.*

U-Bolt clamped splices of both 17 and 21-in. lengths of splice were tested to determine the load at first slip, and the maximum load the splice would resist. Three different classes of splices were thus tested: (1) Lap splices not embedded in concrete; (2) Butt splices not embedded in concrete; and (3) Lap splices embedded in concrete.



Method of Embedding Bar in Concrete.

The reinforcement steel in all cases consisted of 1-in. square cold-twisted bars.

The loads necessary to produce first slip had a range of from 7,000 to 50,000 lb. The maximum loads which the splices withstood varied from 23,000 to 69,000 lb. The ratios of load at first slip to yield point of bar for clamped splices not embedded in concrete varied from

TABLE 1.—SUMMARY OF TESTS ON U-BOLT CLAMPED SPLICES

				Relative Efficiency.	
Kind and condition of splice.	Load at first slip, lb.	Maximum load, lb.	Slip at maximum load in gage length, per cent.	Rattio of first slip to yield point of bar, per cent.	Ratio of maximum load to tensile strength of bar, per cent.
Lap; not embedded in concrete	9,970-11,570	40,050-44,340	9.9-23.0	16.5-19.2	55.1-61.0
Butt; not embedded in concrete	6,950-12,450	22,760-31,650	5.5-26.6	11.5-20.6	31.3-43.6
Lap; embedded in concrete....	32,000-50,000	57,180-68,950	3.2- 7.3	53.1-83.0	78.7-94.9

Note.—The average yield point of the reinforcement bars (1-in. square cold-twisted) was 60,360 lb. per sq. in.; the average tensile strength, 72,685 lb. per sq. in.

---

*Extract from a paper by E. L. Lasier before the American Society for Testing Materials, June, 1916.

embedded splices, and from 79 to 95 per cent for embedded splices.

The conclusions which may be drawn from the tests are as follows:

(1) The 4-in. difference in lengths of lap tested, of one bar upon the other, apparently does not affect the rigidity or strength of the splice.

(2) The clamped lap splices not embedded in concrete sustain, on the average, a slightly greater load before first slip, and a larger maximum load, than the clamped butt splices.

12 to 21 per cent, and for splices embedded in concrete from 53 to 83 per cent. Ratios of maximum load to tensile strength of bar ranged from 31 to 61 per cent for unembedded splices, and from 79 to 95 per cent for

(3) Splices consisting of two bars of opposite twist probably sustain a greater load before first slip, and a larger maximum load, than do splices in which the bars have like twist.

(4) When U-bolt clamped lap splices (of the type, size and lengths herein reported upon) are embedded in masses of concrete similar to those of the test specimens, the splices may be expected to withstand a stress before first slip equal to at least one-half the yield-point stress of the continuous reinforcement bar. Also, the maximum strength of such splices is probably equal to at least three-fourths of the tensile strength of the bar.

(5) When U-bolt clamped lap splices (of the type and lengths herein reported upon are embedded in relatively large masses of concrete, it is reasonable to suppose that first slip would not occur, or the splice would not completely fail, before the yield point or tensile strength, respectively, of the reinforcement steel had been reached; for in such cases the splices would undoubtedly fail only by the pulling out of the bars along the grooves (either through untwisting or through direct shear), and not by splitting of the surrounding concrete. In either case, unlike the results in the tests, the clamps would remain embedded in the concrete, unless the concrete prism directly compressed by the area of the upper or lower clamps were pulled out also, a condition which is not in the least likely to occur with a relatively large mass of concrete.

(6) Hence, for purposes of design, it is probable that such U-Bolt clamped lap splices, embedded in concrete under conditions ordinarily obtaining in actual practice, could safely withstand a unit load equal to the allowable unit stress in the steel reinforcement bars.

DIAGRAMS FOR THE DESIGN OF REINFORCED CONCRETE T BEAMS.

Contributed by M. A. Drucker, Division of Designs, Public Service Commission, New York City.

The design of reinforced concrete even by means of the formulas commonly employed, is a long and tedious process. This is particularly true of T beams. It is not surprising, therefore, that many attempts have been made to simplify the design of such beams by means of prepared tables or diagrams. Of those that have come to the writer's attention, none are of general application. The following diagrams, however, have no limitations beyond those governing the formulas themselves; i. e., some things must be given or assumed from which the complete design is determined.

In order that diagrams may be used intelligently, it is necessary that a knowledge be had of the method pursued in preparing them. For this reason a brief explanation of their construction will be given.

The linear law of compression on the concrete was assumed; the compression on the web and the tension in the concrete were neglected, giving the following formulas:

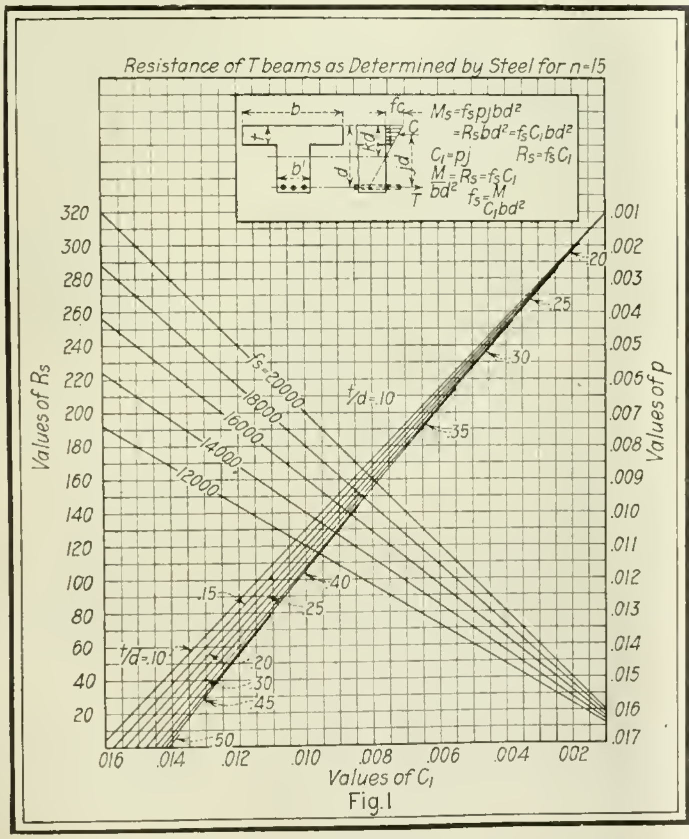


Fig. 1.

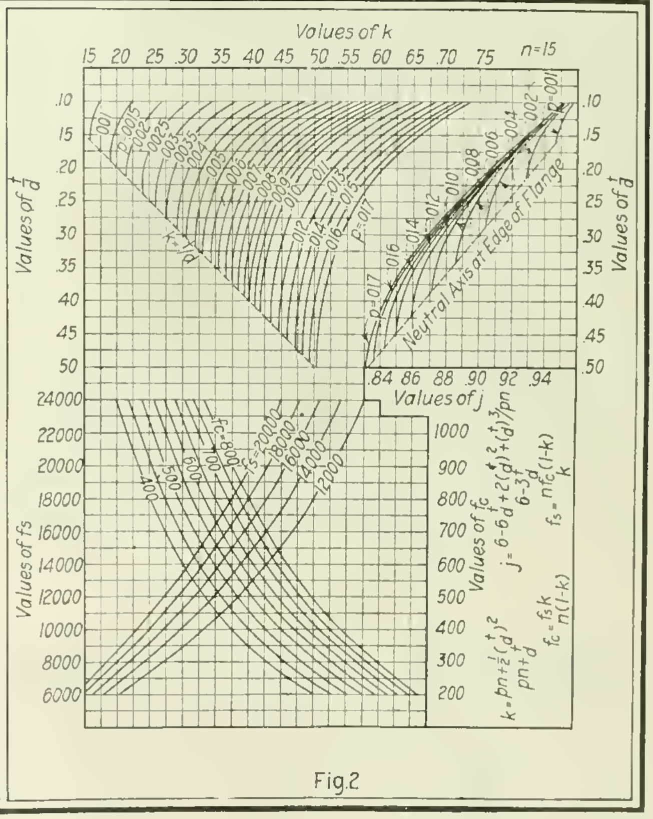


Fig. 2.

$$k = \frac{pn + \frac{1}{2}\left(\frac{t}{d}\right)^2}{pn + \frac{t}{d}}, \qquad j = \frac{6 - 6\frac{t}{d} + 2\left(\frac{t}{d}\right)^2 + \left(\frac{t}{d}\right)^3/pn}{6 - 3\frac{t}{d}}$$

in which the symbols are those commonly employed.

Values of "k" and "j" were computed for different values of t d and various percentages of steel as shown on Diagram 2. Diagram 1 was constructed by obtaining values of pj for the values t d shown; pj is called C_1 at bottom of sheet. $R_s = f_s C_1$, giving straight lines for the different stresses in the steel. For diagram 3 values of

$$C_2 \left[= \left(1 - \frac{t}{2kd}\right) \frac{t}{d} \times j \right]$$

were plotted and given at bottom of sheet. $R = f_c C_2$.

From the lower left hand corner of Diagram 2, values of f_c (given at right side) may be obtained corresponding to the plotted values of f_s for any values of t d and p given on diagram above. Similarly values of f_s (given at left side) may be obtained corresponding to the plotted values of f_c. The use of this diagram will be explained later.

To show how the diagrams are to be used, several illustrative examples will be worked out.

(1) Given b = 50 in., d = 25 in., t = 8 in., steel area = 4.71 sq. in.

$f_s = 16{,}000$ lb., $f_c = 600$ lb. Find resisting moment of beam.

$$p = \frac{4.71}{50x25} = .00377,\ \frac{t}{d} = \frac{8}{25} = .32,\ bd^2 = 50x(25)^2 = 31{,}250.$$

Starting at left of Diagram 2 for t/d = .32 and moving horizontally towards the right, it is seen that a value of p = .00377 would be reached before passing the line of k = t/d, which shows that the neutral axis is in the flange and the problem is, therefore, that of a simple beam.

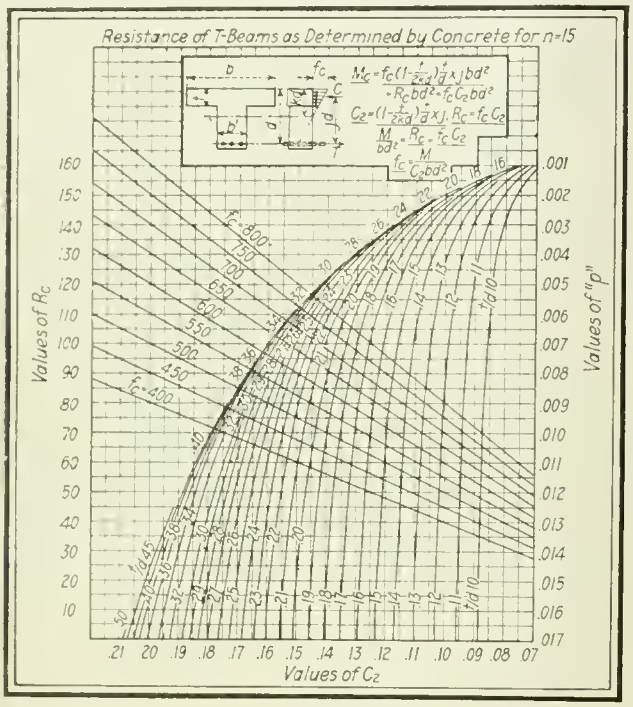


Fig. 3.

(2) Same as (1) except t = 6 in., $\frac{t}{d} = \frac{6}{25} = .24$.

Proceeding as above it may be seen that the neutral axis is below the flange. Starting at right of Diagram 1 for p = .00377, and moving towards left until meeting t/d = .24, then moving down vertically to $f_s = 16{,}000$ and read $R_s = 54.5$ at left of sheet. $M_s = 54.5x31{,}250 = 1{,}704{,}000$ in.-lb. Similarly, starting at right of Diagram 3 for p = .00377 and moving horizontally until meeting t/d = .24, then moving down vertically to $f_c = 600$ and $R_c = 76$ at left of sheet. $M_c = 76x31{,}250 = 2{,}370{,}000$ in.-lb.

(3) Given the same beam as in Problem 2 subjected to a combined bending moment due to dead and live loads = 1,600,000 in.-lb. Find f_s and f_c. $\frac{M}{bd^2} = \frac{1{,}600{,}000}{50x(25)^2} = 51.2.$

Starting at right of Diagram 1 for p = .00377, and moving towards left until meeting t/d = about .24 and reading $C_1 = .00342$ at bottom of sheet. $f_s = \frac{51.2}{.00342} = 15{,}000$ lb., and starting at right of Diagram 3 for p = .00377, and moving towards left until meeting t/d = .24 and reading $C_2 = .127$ at bottom of sheet. $f_c = \frac{51.2}{.127} = 405$ lb.

(4) Given b = 40 in., t = 5 in., M = 800,000 in.-lb. Maximum allowable stresses: $f_s = 18{,}000$ lb., $f_c = 800$ lb. Find d and p. Assuming d = 20 in., $\frac{M}{bd^2} = \frac{800{,}000}{40x(20)^2} = 50 = R_s$, $\frac{t}{d} = \frac{5}{20} = 25.$

Starting at left side of Diagram 1 for R = 50, and moving towards right until reaching $f_s = 18{,}000$, then moving vertically upwards to t/d = .25, and reading at right of sheet p = .0031. Now start at left side of Diagram 2 for t/d = .25 and moving horizontally until reaching p = .0031, then vertically down to $f_s = 18{,}000$ and reading at right $f_c = 435$ lb., which is less than the maximum allowable. Therefore, Diagram 3 need not be used. Also starting at right side of Diagram 2 for t/d = 25, and moving horizontally until reaching p = about .0031, and reading at bottom j = .915. If the shear be 25,000 lb., and the maximum allowable unit shear, considering web reinforcement, be 120 lb. per square inch, then $b' = \frac{25{,}000}{.915x20x120} = 11.4$ in.

(5) Given M = 600,000 lb., shear = 20,000 lb., b = 24 in., d = 18 in. Maximum allowable stresses as follows: $f_s = 14{,}000$ lb., $f_c = 500$ lb., shear = 120 lb., bond = 80 lb. Find t, b' and p.

Comparing with previous designs 4 1-in. round rods will be assumed. $p = \frac{4x.7854}{24x18} = .00728.\ \frac{M}{bd^2} = \frac{600{,}000}{24x(18)^2} = 77.2.$ Starting at left side of Diagram 3 for $R_c = 77.2$, and moving horizontally until reaching $f_c = 500$ lb., then vertically upwards until p = .00728. t/d is found to be .265, t = .265x18 = 4.77 say 5 in., then $t/d = \frac{5}{18} = .278.$

Starting at left side of Diagram 2 for t/d = .278, and moving horizontally until reaching p = .00728, then moving vertically down until $f_c = 500$ and reading $f_s = 12{,}300$ at left side of sheet, which is less than the maximum stress allowed. For t/d = .278 and p = .00728, Diagram 2 shows j = .885, $b' = \frac{20{,}000}{.885x18x120} = 10.4$ will be made 12 in. to permit spacing of rods. Unit bond stress $= \frac{20{,}000}{.885x18x4x3.142} = 100$ lb. The beam can now be redesigned taking into account its own weight.

(6) Same as Problem 2, excepting $f_s = 15{,}000$ lb. per sq. in. Starting at right side of Diagram 1 for p = .00377, and moving towards left until meeting t/d = .24 and reading $C_1 = .0034$ at bottom of sheet, which gives $M_s = 15{,}000 \text{ x } .0034 \text{ x } 50 \text{ x } (25)^2 = 1{,}595{,}000$ lb.

A case as illustrated by Problem 5 occurs but seldom, for usually the flange, being part of the floor system, is known before beginning the "T" beam design. For ordinary cases, only Diagram 1 need be used to determine the area of steel required, and Diagram 2 to find value of j and also f_c corresponding to f_s used in design.

For unit stresses not plotted on Diagram 1, values of C_1 should be used as illustrated in Problem 6.

If preferred, values of C_1 and C_2 on Diagrams 1 and 2 may be used instead of R_s and R_c, even when the stresses used are plotted on the diagrams, thus making it unnecessary to follow two sets of curves. These values may then be substituted in the formulas given on Diagrams 1 and 2.

REPAIRING MACADAM WITH TRACTION HAULING OUTFIT.

An economical method was used by John F. Gallier, County Highway Superintendent of Wood County, Ohio, in repairing a 10-mile water-bound macadam road near Grand Rapids, Ohio. The work was described by Mr. Gallier in a paper presented at the March meeting of the Northwestern Ohio County Surveyors' Association. The road was surfaced for a width of 12 ft. about 12 years ago. Some repairs were made about 6 years ago, but since then nothing further had been done. The road was repaired late last fall. At that time all macadam road rollers owned by the county were working in other localities and it also was impossible to obtain a roller from construction. As a result, a steam hauling outfit, consisting of a 12-ton traction engine and four 9-yd. trailer wagons, equipped with 12-in. steel tires, was hired at a rate of $25 per day. Number 4 and Number 7 stone (mixed) was shipped to a point about the center of the road to be repaired. The stone was unloaded with a Galion unloader, being discharged directly from the hopper into the 9-yd. cars. Spreading was commenced at the point in the road nearest to the hopper. Each succeeding load was hauled over this stone that already had been spread on the road. After a few loads had been dumped on the road, an engine hitch was used so that the trailers would not track. A road girder was used behind the trailers when dumping for leveling the stone. With the exception of the last few loads of stone on the ends of this road, the hauling, spreading and rolling was completed in one operation. The average haul was 2¾ miles and about 154.8 tons of stone were used per mile of road. The cost of the repair work was $240 per mile. The unit costs per ton of stone were as follows:

	Per ton.
Stone in bin at quarry	$0.60
Freight	.20
Unloading	.10
Hauling, spreading, rolling, etc.	.65
Total	$1.55

ARTIFICIAL MEANS OF SEWAGE TREATMENT.*

The objects of artificial treatment, with the methods by which they are attained, may be classed as follows:

A. To prevent waters into which sewage is discharged from becoming offensive to the eye on account of coarse floating and suspended matter.
 Screening.
  (a) Coarse.
  (b) Fine.
B. To prevent such waters from becoming malodorous.
 1. Sedimentation.
  (a) Rapid in grit chambers.
  (b) Slow in settling basins.
   Plain.
   With septic action in single-story tanks.
   With sludge digestion in two-story tanks.
   With chemical precipitation.
   With electrolysis and chemical precipitation.
   With colloiders.
 2. Aeration, contact with the organisms or sludge from previously aerated sewage, and sedimentation.
 3. Contact bed treatment.
 4. Trickling filter treatment.
 5. Intermittent filtration.
 6. Broad irrigation
C. To prevent the introduction into the water of germs of disease.
 Disinfection.

The treatment of sewage may be accomplished by a single process in some cases, but usually it is effected by a series of steps, the degree of purification increasing with each successive stage. If raw sewage may be discharged into natural waters without creating objectionable conditions other than offending the sense of sight, the simple process of screening may suffice, but if it is necessary to remove more of the matters likely to settle, sedimentation may be adopted as an adjunct to or substitute for screening. Where the diluting waters are so limited in quantity that it is necessary to supplement their powers of oxidation, some method of artificial oxidation must be adopted; such, for example, as filtration through beds of sand or stone which form the habitat of bacteria and other organisms capable of bringing about the more or less complete and rapid oxidation of the organic matter of the sewage. Under still more exacting conditions it may be necessary to go further with the removal of pathogenic organisms. The final process would then be disinfection, through which a large proportion of the harmful bacteria may be eliminated even from settled sewage. In such a case the treatment would involve four successive steps, namely, screening, sedimentation, oxidation by filtration or other means, and disinfection.

Screening.

Municipal sewage contains many relatively large and coarse substances such as cloth, paper, garbage and pieces of wood, which may interfere with pumping and other machinery and prove unsightly in the waters into which the sewage is discharged.

Such substances may be removed by coarse screens, which often consist simply of parallel iron bars, or gratings, set vertically or at an angle of from 30 to 60 degrees with the horizontal, through which the sewage flows and upon which the very coarsest of the suspended and floating matter is retained.

Coarse screens will remove only from 5 to 10 parts per million of suspended matter originally contained in the sewage. This is usually sufficient for the protection of machinery and is regarded as sufficient for all purposes in some cases where sewage is discharged into large quantities of diluting water, as into the tidal waters of Boston Harbor off Nut Island.

If, however, sewage is to be discharged in relatively large quantities into waters used for boating and other pleasure purposes, coarse screens cannot be relied upon to remove all of the suspended matters which are recognizable as being of sewage origin and which, therefore, may be considered as offensive to the sight. Where such substances must be removed and also where a somewhat greater reduction in the organic matter is required, fine screens may be used, either by themselves, or supplementary to the coarse screens. Numerous types of fine screens have been perfected and placed upon the market, among which may be mentioned the Weand screen, first installed at Reading, Pa.; the Jennings screen, used at the Union Stock Yards in Chicago; and the Riensch-Wurl screen used in Germany and being installed to a limited extent in this country. The Weand screen consists of a horizontal revolving drum covered with a fine mesh screen. The sewage is discharged into this drum at one end and flows out through the cloth, which retains the suspended matter until it is washed off into suitable receptacles by jets of water. The Jennings screen is of the moving band type, the lower end being submerged in the sewage, which flows through the screen cloth, which retains the suspended matter and carries it up out of the sewage. When the screen has passed over the pulleys at the top, the screenings are blown off into a pit by a jet of compressed air applied to the back side of the screen. The Riensch-Wurl screen which is typical of its class consists of a disk of perforated metal, with or without a frustum of a cone attached to its center, the whole being mounted on a shaft whose inclination from the vertical determines the degree of tilting of the disk. As the screenings are raised above the surface of the sewage by the revolving disk and cone they are swept into a circular gutter, by brushes on the ends of the arms of a large spider. Where the screen is surmounted by the frustum of a cone the side of the cone is cleaned by a brush inclined against its surface.

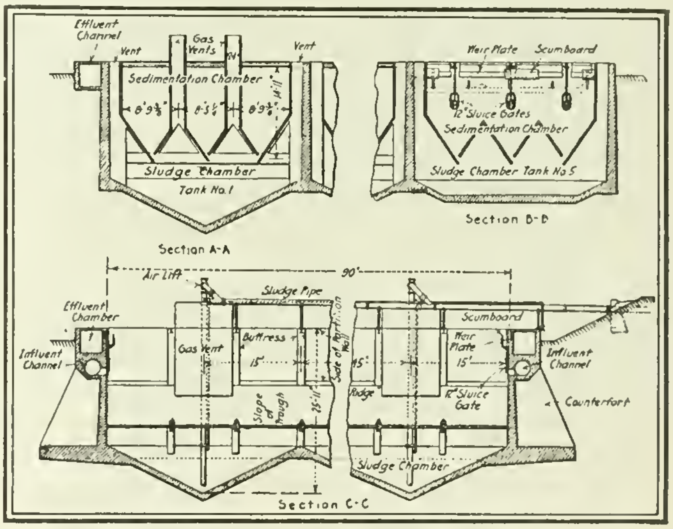


Fig. 1—Section of Imhoff Tank.

The quantity of suspended matter removed by fine screens varies with their efficiency and the quality of the sewage. Such screens may remove from 20 to 70 parts, averaging perhaps 50 parts per million of suspended solids.

---

*From a paper by Harrison P. Eddy, of Metcalf & Eddy, Consulting Engineers, Boston, Mass., in the Proceedings of the Engineers' Society of Western Pennsylvania for April, 1916.

Sedimentation.

It has been claimed sometimes that with the most effective fine screens the organic matter may be removed to such an extent as to greatly reduce the oxygen requirements of the sewage, and thus make it possible to dispose of a much greater quantity of screened than of raw sewage in a given quantity of diluting water. The concensus of opinion, however, appears to be that while the reduction of organic matter by fine screenings may be considerable, it will not be enough to greatly increase the quantity of sewage which a given stream or body of water may receive and remain in a satisfactory condition. Grounds for this opinion will be apparent when it is considered that much of the coarse suspended matter in sewage consists of materials like paper, matches and coffee grounds, which are relatively stable organic substances and which do not constitute so great a tax upon the diluting power of the water as equal quantities of fecal and other polluting substances which are more finely divided and consequently which are not so completely removed by screens. Therefore, where it is necessary to increase the quantity of sewage which may be discharged into a body of water, sedimentation in some form is generally adopted.

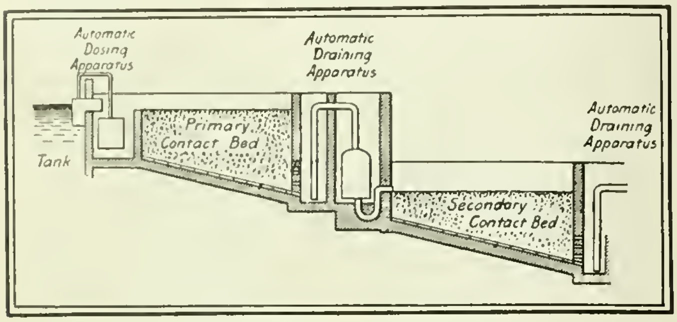

Automatic Dosing Apparatus
Automatic Draining Apparatus
Automatic Draining Apparatus
Primary Contact Bed
Tank
Secondary Contact Bed

Fig. 2—Double Contact Bed.

Grit Chambers.—The grit chamber ordinarily is merely an adjunct to the main process of sewage treatment, its function being to remove the coarser sand and gravel commonly called grit, which might cause excessive wear of moving parts of machinery, or cause deposits in tanks or elsewhere which would prove more expensive to remove from such tanks than from grit chambers. There is much diversity in the design of such chambers, the older ones and those most commonly in use in England being so large that they permit the sedimentation not only of the grit or mineral matter, but also of much of the organic sewage matter. Such deposits are relatively large in quantity and exceedingly offensive in character. They are removed by manual labor, being shoveled, after draining, into buckets, or they may be dredged by various types of excavators capable of removing the grit from beneath the surface of the sewage, thus avoiding the emptying of the chambers. The more modern type of grit chamber, which may fairly be said to have originated in Germany, consists of one or more narrow channels through which the sewage is allowed to flow at velocities closely approximating 1 ft. per second, at which the sand and gritty matter will deposit. These chambers are in turn shut off and drained, and the grit removed, ordinarily by manual labor. Under the best conditions this grit consists of a mixture of various sizes of sand comparatively little of which is finer than ordinary mortar sand. It contains relatively little organic matter, perhaps from 15 to 25 per cent, and is less offensive than the grit removed from the larger and older type of chambers, where the velocity of flow is much lower. The quantity of grit removed will vary roughly between 10 and 40 parts per million.

Plain Sedimentation.—Plain sedimentation may be assumed to mean the process by which sewage is allowed to flow through horizontal or vertical tanks at velocities sufficiently low to permit substantially all of the suspended matter capable of settling in a reasonable length of time, to fall to the bottom of the tank, where it accumulates in the form of mud, commonly called sludge.

It is necessary to remove this accumulation from time to time and it may be said in a general way that a plain sedimentation tank should be cleaned at intervals of from 3 to 6 weeks, depending upon the season of the year, or, more accurately, the temperature of the sewage. The object is to remove the sludge before decomposition becomes very active and causes portions of it to rise through the sewage, form a well-defined scum, or pass out of the tank in the effluent.

Septic Tank Treatment.—The septic tank, a patented device, is similar to the plain sedimentation tank; in fact there is scarcely any difference between the two except in the method of operation. The septic tank is distinguished by being so operated as to ensure the absence of dissolved oxygen in the effluent and to permit of more or less complete decomposition of the solid substances in the sludge. This decomposition is accompanied by the production of large quantities of gas, due to biological action, and the gases are retained until the mass becomes sufficiently bouyant to rise rapidly to the surface, sometimes giving to the tank the appearance of ebullition. With these gases also rise large quantities of suspended matter, much of which is relatively coarse, especially if the sewage has not been screened, or has been screened only through coarse racks. This suspended matter holds entrained the gases, which in turn cause it to float at the surface of the tank. Repeated ebullitions of this kind cause the gradual accumulation of greater and greater quantities of this floating coarse suspended matter, which ultimately forms a thick scum attaining in some cases a thickness of two feet or more.

The septic tank, which at one time was looked upon with favor by some engineers, did not prove as satisfactory as was originally anticipated. The continuous evolution of gas from the sludge causes large quantities of suspended matter to be continually rising and falling through the liquid in the tank, which carries much of it out of the tank, thus defeating in part the object of the process. Furthermore, the changes due to anaerobic decomposition of organic matter appear to render the sewage rather more difficult to treat by process of oxidation than fresh sewage which has not become impregnated with the gases and other products of decomposition. Septic sewage also frequently possesses an exceedingly offensive odor.

Two-Story Tanks.—A recognition of the defects in the septic process lead to the construction of two types of two-story tanks: one, by Mr. William O. Travis of Hampton, England, and another by Dr. Karl Imhoff of Essen, Germany. The theory upon which these types of tank is based is that the sewage should be allowed to pass through the sedimentation chamber as rapidly as is compatible with the practically complete removal of the suspended matter capable of settling in a reasonable length of time and that the sludge should be permitted and encouraged to decompose in a chamber separate and distinct from that in which the sedimentation process is going on. The result of this plan is an effluent deprived of its suspended matter, and which has not come in contact with the decomposing sludge, and therefore does not contain the gases and other products of decomposition, nor the finely divided suspended matter so prevalent in effluents from

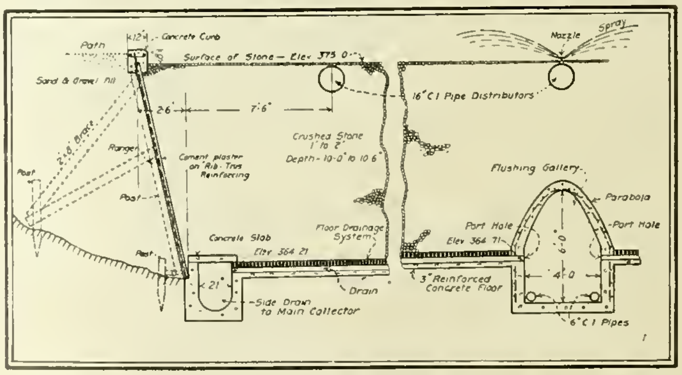


Fig. 3—Trickling Filter.

the septic tank. In fact where sewage is rather dilute and the temperature is moderate the effluent from such tanks frequently contains dissolved oxygen. Sections of the Imhoff tank are shown in Fig. 1.

Work Performed by Sedimentation.—It may be assumed that of the 150 parts suspended solids capable of settling in two hours, perhaps 130 parts can be removed by efficient plain sedimentation. This is based on a tank efficiency of about 90 per cent, computed upon the removal of settling solids. Upon this assumption the effluent will contain suspended colloidal matter which, together with the remaining settling solids, will amount to about 170 parts per million. In addition the effluent will contain about 500 parts of dissolved solids, of which about 50 parts has been classified as dissolved colloidal matter, 40 per cent of which may be assumed to be organic.

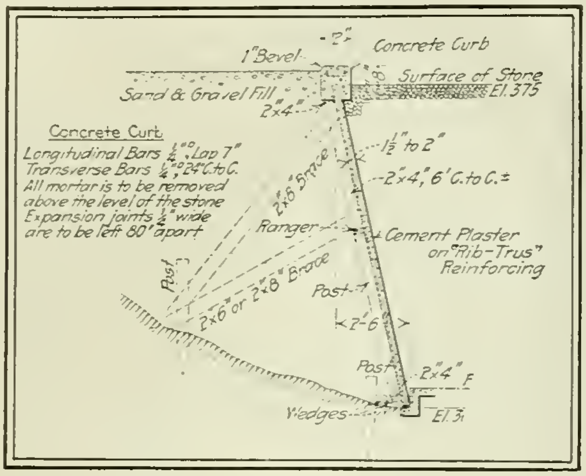

1" Bevel
2"
Concrete Curb
8"
Surface of Stone El. 375
Sand & Gravel Fill
2"x4"
Concrete Curb
Longitudinal Bars ¼"°, Lap 7"
Transverse Bars ¼"°, 24" C. to C.
All mortar is to be removed above the level of the stone
Expansion joints ½" wide are to be left 80' apart
1½" to 2"
2"x8" Brace
2"x4", 6' C. to C. ±
Ranger
Cement Plaster on "Rib-Trus" Reinforcing
Post
2"x6" or 2"x8" Brace
Post
2'-6"
Post
2"x4"
F
Wedges
El. 3

Fig. 4—Wall of Trickling Filter.

Chemical Precipitation.—If further improvement is desired a part of the remaining settling solids, suspended colloidal solids and dissolved colloidal substances may be removed. To accomplish this recourse was had many years ago to chemical precipitation. This consists of adding to the sewage certain chemicals like lime and sulplate of iron, which react upon each other in such a manner as to form a flocculent precipitate, which gathers in large flocculi which enclose and attract the finely divided suspended matter and some dissolved colloidal matter, and by their weight carry these substances to the bottom. In this way it is possible to greatly reduce the suspended solids and to effect some reduction in the so-called dissolved matter. This method has been subject to much objection on account of cost, the difficulty of disposing of the large quantity of sludge produced and of the partial removal, only, of the organic matter contained in the original sewage. Chemical precipitation is generally utilized by itself, although in some cases, particularly in the treatment of industrial wastes, it may be introduced as an adjunct to and following plain sedimentation and it may be used as a treatment preliminary to some method of filtration.

Sedimentation with Aeration.—The most recent development in the art of removing suspended and colloidal substances from sewage is that known as the "activated sludge process." By this means it is possible to remove from ordinary municipal sewage a large part of the suspended and colloidal matter. As yet the installations are experimental, but are giving promising results. Suspended solids may be removed almost completely in the remarkably short time of four hours or even less. This process will be described in succeeding pages.

Work Performed by Sedimentation Aided by Methods of Removing Colloids.—It has been pointed out that the effluent from efficient plain sedimentation will contain about 170 parts per million of settling and suspended colloidal matter, and about 50 parts of so-called dissolved colloidal matter, making a total of 220 parts per million.

Several ways of removing a portion or the whole of this matter have been suggested, among which may be mentioned sedimentation in tanks equipped with many vertical slats, or colloiders, chemical precipitation and the activated sludge treatment. The last method will accomplish more than is practicable under ordinary working conditions by either of the others, and in addition it will at the same time oxidize some of the dissolved substances; therefore, it cannot fairly be considered as simply a means of removing suspended and colloidal matter.

The most effective method devoted strictly to the removal of such substances, is chemical precipitation, by which much of the settling solids and colloidal matter can be removed. In addition to the 130 parts of settling solids which may be removed by plain sedimentation, about 160 parts of the settling solids and colloidal matter which escapes this process can be removed by chemical precipitation, leaving in the effluent from this process 60 parts per million, or less, of settling and colloidal matters. It is possible to go even further, but the cost of doing so has usually been prohibitive.

The effluent from sedimentation tanks may be discharged with propriety into some bodies of diluting water, but in many cases it is necessary to carry the process of purification further. Where chemical precipitation will provide a suitable effluent the choice between this method and some means of oxidation will depend upon their relative costs. In many cases, however, the effluent from chemical precipitation will not be adequately purified and it will be necessary to resort to an oxidation process. The failure of various tank treatments to remove fine suspended and colloidal matter and the necessity of oxidizing the organic matter of tank effluents before their discharge into natural waters, led to the development of processes for transforming this organic matter into stable substances, the demands of which for oxygen are not great enough to exhaust the supply or cause putrefaction.

Contact Bed Treatment.

Perhaps the most logical step ahead from tank treatment is the application of sewage to the contact bed. Such beds are built in water-tight compartments filled with broken stone or other similar medium to which bacteria become attached. The mass of stone is thus converted into an active bacterial medium over which the sewage gradually flows during the filling and discharging periods, and in contact with which it remains during the contact period. Such beds are operated in cycles of which the following is typical:

Time of filling	1.0	hour
Time of contact	0.75	"
Time of emptying	0.25	"
Time of resting	6.00	"
Time of cycle	8.00	"

While the sewage is in contact with the bacterial film or jelly surrounding the stones, its colloidal and dissolved substances are attracted to these films in which the bacteria are living and digesting the organic matter, thus brought to them. The changes which occur in the contact bed apparently consist of the initial removal of suspended and colloidal matters, its partial oxidation and the oxidation of matters in solution. By this process it is possible to so change the character of the sewage that even when undiluted it will remain stable or, in other words, will fail to putrefy, and may, therefore, be discharged into streams or bodies of water much smaller than those into which ordinary sedimentation tank effluent could properly be discharged. The effluent, however, is usually turbid, contains some suspended matter and is far from being fully oxidized. This process, which has met with some favor, both in this country and abroad, usually provides for two contacts, the sewage being applied to a secondary bed after it has remained in the primary bed during the requisite period of contact. Figure 2 shows a typical double contact bed.

Trickling Filter Treatment.

The oxidizing power of all bacterial agencies depends upon an ample supply of atmospheric oxygen. This must be absorbed by the bacterial jelly of the contact bed, mainly during the rest period which is limited to a fraction of the operating cycle, rarely exceeding three-quarters of it. The quantitative efficiency of the contact bed is low also, because of its limited capacity for the storage of sewage in contact with the bacterial surfaces. These limitations have led to efforts to devise beds which would accomplish similar work without being subject to such restrictions. The most important derivative of the contact bed is the trickling filter.

Like the contact bed, this filter is composed of coarse grained particles, the most popular size at present perhaps being 1½ in. in longest dimension. The thickness of the beds varies from 5 to 10 ft., and their shape depends upon the method of distribution or local conditions of controlling importance. The stone is placed upon concrete or vitrified tile draining floors. The sewage is distributed as uniformly as may be over the surface of the bed, by revolving arm sprinklers, distributors moving backward and forward spreading the sewage as they go, or fixed pressure nozzles which spray the sewage, distributing it in a manner similar to that of the ordinary lawn fountain. Where the fixed pressure nozzle is used it is generally operated under a head diminishing throughout the discharge period from a maximum of about 7 ft. to the minimum, which varies from 1 to 2 ft. The dosing cycle may consist of a 5 minutes' dosing period and a 10 minutes' rest period.

This fluctuation in head may be obtained by a butterfly or undulating valve, rotated in the supply main, or by dosing tanks so designed as to provide the proper quantity of sewage at each head.

When sewage is first applied to a new trickling filter the suspended matter clings to the surface of the stones where it is temporarily retained, forming a suitable habitat for the bacteria present in the sewage. Thus a bacterial film, sometimes called bacterial jelly, is gradually built up, covering the surface of the stone of the entire bed. As the sewage trickles over this jelly-like substance, the finely-divided colloidal and some of the dissolved matter is retained upon and in it and apparently furnishes the food supply for the myriads of micro-organisms present. In this manner the sewage is deprived of its putrescible organic matter, which is gradually worked over by the organisms and ultimately given off to the passing sewage and carried away in the form of mineral or stable organic substances. It is of vital importance to provide the proper quantity of food supply and an ample opportunity for the absorption of atmospheric oxygen. The operation of the filter is approximately continuous, and thus has a distinct advantage over the contact bed, which of necessity is both dosed and aerated periodically. A typical section of a trickling filter is shown in Fig. 3.

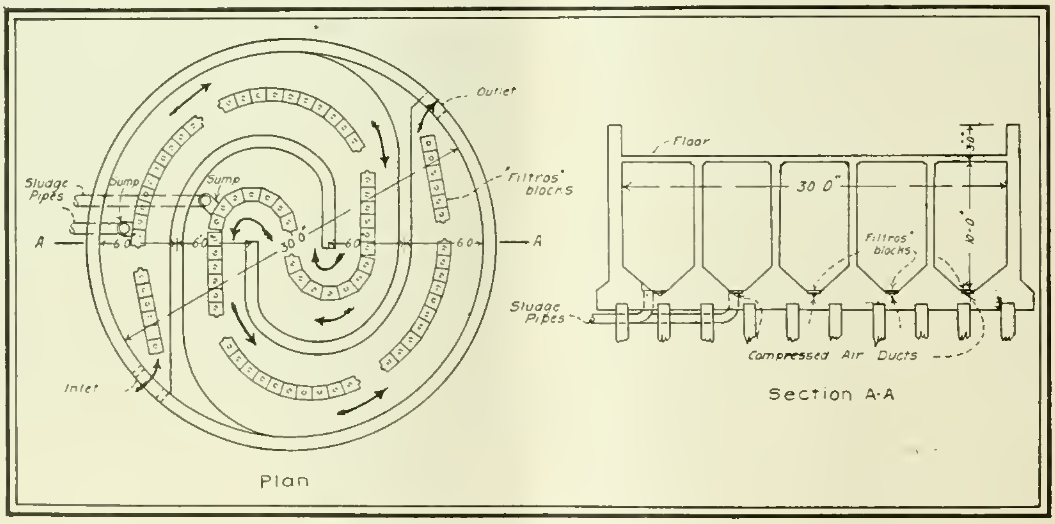


Fig. 5—Activated Sludge Tank.

A very highly efficient trickling filter will carry the process of oxidation so far that the effluent will keep indefinitely, and if the contact material is relatively fine, the suspended matter of the sewage and the collodial matters withdrawn therefrom will be retained and a practically clear and sparkling effluent will be produced. Such a filter will cause a large reduction in the number of bacteria present in the original sewage. Trickling filters are ordinarily built of coarse stone, however, and contain interstices so large that the suspended matter which accumulates temporarily passes away after having been more or less completely worked over by the organisms. Such effluents are turbid and contain settling solids which are commonly removed in secondary sedimentation tanks. In fact, one of the primary objects in the design of trickling filters is to so construct them that the solids shall not accumulate indefinitely in the stone, but may wash out from time to time and thus avoid the necessity of taking out the stone to free it from the accumulation of such substances which otherwise might ultimately clog the filter. It is necessary, therefore, under ordinary conditions, to accept turbidity and much suspended matter, as characteristics of the effluent from this type of filter, and to provide for the removal of the settling solids before its discharge into the diluting waters.

The underdrainage system of the trickling filter is of great importance, since it is necessary to convey the effluent away freely, and also to provide ample means for washing out humus when the bed discharges its accumulation. Many types of filter floor have been used for this purpose. The one used at Fitchburg, Mass., consists of a series of channels cast in the concrete floor, spanned with concrete beams or "bricks," the whole being covered with cobble stones before the filtering material was placed.

The walls of such a filter, if below the ground level, need be hardly more than diaphragms to prevent the material of the filters from mingling with the adjoining earth, and to keep the sewage or effluent from escaping into the soil. Such a diaphragm wall, built by plastering reinforcing steel with mortar by means of the cement gun, was employed at Fitchburg, and is shown in Fig. 4.

Sand Filters.

The intermittent sand filter is one of the oldest devices for the artificial treatment of sewage. It consists of a bed of sand from 3 to 5 ft. in depth, enclosed within embankments and usually provided with underdrains. It is necessary to use a free draining sand, if filters are to be capable of handling a reasonable quantity of sewage.

As the name implies, these beds are operated intermittently. They are dosed by completely flooding the surface as quickly as possible, preventing excessive quantities of sewage from penetrating portions of the bed near the distributors, and thus aiding in uniform distribution. Dosing is best accomplished in the smaller plants by storing the sewage until the desired quantity has accumulated, when the dose is suddenly and quickly released by automatic apparatus.

The sewage percolates through the sand, where it comes in intimate contact with living organisms, as in the contact and trickling filters. In fact, the biological processes appear to be practically identical in these types of filters, although the oxidation is usually carried somewhat further in the sand beds. There is, however, one distinct difference between the sand filter and the trickling filter as ordinarily constructed and operated. The former, due to its fine particles and small interstices, retains the suspended solids mechanically, and is thus enabled to produce an effluent which is clear, sparkling and colorless. The trickling filter, as already explained, because of its large interstices, allows the suspended matter ultimately to pass through it, giving to the effluent a decidedly turbid appearance. A well-operated sand filter will carry the oxidation of the organic matter nearly to completion, converting it very largely into mineral substances. The bacterial reduction may also be far superior to that obtained by ordinary types of contact and trickling beds. Effluents in fact are obtained in which the bacteria are less than 1 per cent of the number present in the original sewage, a result fully equal to that obtained by ordinary disinfection.

Obviously the retention of the suspended matter upon and in the sand causes a reduction in its capacity, and if this accumulation is permitted to increase indefinitely, the filter will become practically impervious to water. It is necessary, therefore, to provide for the periodic cleaning of the filters, which is accomplished by raking and scraping off the mat remaining upon the surface of the sand after the filter has become dry. Heavy mats necessitate frequent and expensive cleaning, which may be reduced, to some extent, by passing the sewage through sedimentation tanks before it is applied to the filters. It is usual, therefore, in such installations to combine with the sand filter suitable sedimentation tanks for the removal of the coarser suspended matter.

The efficiency of sand filters, as well as of contact beds and trickling filters, is much lower during cold weather than in the summer. It is necessary to make ample provision for winter conditions, to avoid the freezing of the applied sewage in a solid layer adhering to the surface of the beds. This is accomplished by furrowing or by raking the surface material into piles, so that the ice sheet may be held up above the normal surface, thus providing a natural roof or cover, below which the sewage flows to the various parts of the bed, and which protects the sand from extreme cold and snow.

Broad Irrigation.

It is hardly necessary to discuss here the merits and demerits of broad irrigation, the oldest method of artificial oxidation of sewage upon land. This method has found little favor in this country.

It is capable, under favorable conditions, of producing a very highly purified effluent—fully equal to that of the sand filter.

Disinfection.

The methods of sewage treatment thus far described deal primarily with the prevention of objectionable deposits and offensive conditions. Disinfection deals with the destruction of organisms. Normal municipal sewage may be said to contain about one million bacteria per cubic centimeter, while they frequently run as high as 10 or 20 million c. c. in old and strong sewages. Of these the great majority are probably harmless. Pathogenic organisms, however, may be present in sewage and the object of disinfection is to kill such organisms, or to so reduce their numbers that they may not be a menace to health.

For this purpose calcium hypochlorite, or bleaching powder, and liquid chlorine, have been used. The quantity required varies according to the quality of the sewage or effluent to be disinfected and the extent to which it is desired to reduce the number of bacteria. The quantity of available chlorine used varies from 3 to 6 parts per million, which is equivalent to 25 to 50 lb. per million gallons of sewage. These quantities of chlorine are equivalent roughly to 75 to 150 lb. of bleaching powder per million gallons of sewage.

This treatment is not likely to produce a sterile effluent, but will reduce the number of bacteria growing at body temperature—37 deg. cent.—from 75 to 90 per cent and the coli from 90 to 95 per cent. Such disinfection has been assumed to be sufficient when the effluent was discharged into tide water above oyster beds and an adequate protection of the public where the discharge was into large streams or bodies of water from which water supplies were taken, provided they were efficiently filtered and disinfected before use.

Activated Sludge Treatment.

During the past two years the attention of sanitary engineers has been focussed upon a new method of sewage treatment known as the activated sludge process. This process appears to have been discoverd accidentally by Messrs. Ardern and Lockett, who presented the results of their original experiments at Manchester, England, in the Journal of the Society of Chemical Industry, May 30, 1914. They found that when sewage was kept for several hours in intimate contact with sewage sludge, by agitation with a current of air, the sludge assumed the form of a light flocculent precipitate, the suspended and colloidal substances were attracted to and absorbed by these flocculi and the dissolved matters were oxidized, the free ammonia being transformed into nitrates.

Milwaukee Experiments.—Many experiments with this method of treatment have been made, the most notable perhaps being those of the Milwaukee Sewerage Commission, of which Mr. T. Chalkley Hatton is chief engineer, and Mr. William R. Copeland is chief chemist.

This process is still in an experimental stage, although at Milwaukee it was thought that sufficient progress had been made to warrant the construction of a 2-million gallon plant, which was completed in December and has been in operation two months. The plant consists of eight round aerating tanks 30 ft. in diameter and of sufficient depth to accommodate about 10 ft. of sewage, including 20 per cent of sludge. Partitions are so arranged as to confine the sewage to channels 6 ft. wide, through which it flows continuously, passing from tank to tank. From the aeration tanks it flows to a sedimentation tank, being admitted at a considerable depth below the surface, and flowing upward to skimming troughs into which it flows in a thin film at the surface of the tank. Two tanks of similar size are provided for the storage and re-aeration of the sludge collected in the sedimentation tank. The plant is also provided with the necessary air blowers and measuring devices. The equipment for handling, dewatering and drying the sludge, has not yet been fully determined upon.

Method of Operation.—While the methods of treatment in different places, vary considerably, the concensus of opinion at the present time (1916) appears to be that operation by continuous flow through the aeration and sedimentation tanks is preferable to the fill and draw method which has been used in some of the smaller experiments. The process can be explained conveniently by describing the method of operation of the new Milwaukee plant as it is intended to be used when certain modifications have been made.

Sewage Aeration.—Sewage flows continuously through the aerating tanks which are provided at the bottom with an air distribution system consisting of ducts above which are placed thin porous plates made by the General Filtration Company. These "filtros" plates are confined to a single row extending along the middle of the sewage channel. The air is admitted to the porous plates under a pressure slightly greater than that exerted by the overlying column of sewage. In this manner the sewage is constantly mixed with the sludge by the rising air, and at the same time the sludge and the liquid are afforded an opportunity to absorb oxygen from the air. Just before the sewage is admitted to the first aeration tank, it receives a dose of activated sludge, equivalent to 20 per cent of its volume. The method of preparing this sludge will be described later.

The period of aeration is intended to be about 4 hours, which obviously corresponds to the length of time required for the sewage to flow through the eight aeration tanks. The quantity of air required for aeration of the sewage appears to be about 1.75 cu. ft. of free air per gallon of sewage treated.

Sedimentation.—As it is important to maintain the sludge in intimate contact with all portions of the sewage in the aerating tanks, it is necessary to provide for sedimentation immediately after the sewage leaves them. The flocculent precipitate, however, settles quickly and a clear effluent can be obtained from suitable sedimentation tanks. It is expected at Milwaukee to reduce the quantity of suspended matter in the sewage to less than 20 parts per million, as the effluent leaves the sedimentation tank. The suspended matter gradually falls to the bottom where it accumulates as a thin sludge.

Sludge Handling.—From the sedimentation tank in which the sludge naturally contains 98 or 99 per cent water, the sludge flows to a deep concentration well where it is hoped to reduce the water content to 96 per cent or less. From this well the sludge may be pumped into the incoming sewage or, when necessary, to the sludge reservoirs where it is continuously aerated to reactivate it before pumping it to the raw sewage.

There are as yet very few data to indicate the quantity of sludge likely to be produced by the activated sludge treatment of sewages in general. The Milwaukee experiments indicate that the quantity will range from 3,000 to 6,000 gal. per million gallons of sewage treated. This sewage is relatively strong, its volume being equivalent recently to about 80 gallons per capita per day. It contains considerable industrial wastes and may produce an abnormal quantity of sludge.

Analyses of this sludge indicate that when dry it contains sufficient fertilizing ingredients to make its utilization commercially attractive. There are, however, serious difficulties to be overcome in dewatering and drying the sludge. Very little progress has been made upon this phase of the problem.

Theory of Action.—The most noticeable effect of this treatment upon the sewage, is the formation of the precipitate called "activated sludge." It is light brown in color, apparently very light in weight, and readily forms loose aggregations called "flocculi," resembling precipitated hydrate of iron. These flocculi are found to contain vast numbers of bacteria, which appear to be absolutely essential to the success of the process. It is conceivable that they exude certain substances which give to these flocculi their peculiar absorptive and attractive functions, and which enable them, while passing through the sewage, to gather to themselves the colloidal matter and bacteria, and to absorb certain of the dissolved substances.

The action of this sludge appears to be very similar to that of the bacterial jelly surrounding the stones of the trickling filter. The chemical changes which go on in the sewage, in both processes, appear to be practically identical. The efficiency, however, of the activated sludge flocculi, in holding the colloidal matters, appears to be greater than that of the bacterial jelly of the trickling filter, for the effluent from the aeration tanks, after proper sedimentation, is very clear and sparkling, while the effluent from ordinary trickling filters, even when in relatively good condition, is almost always turbid, even after the settling solids have been removed from it by sedimentation. The two processes, although very similar in theory of action, are carried on under different physical conditions. In the case of the trickling filter, the sewage is the moving medium, passing slowly over the absorbing jelly, by which its finely divided particles and some of the dissolved matter are absorbed, and subjected to bacterial decomposition and oxidation. In the aerating tanks, on the other hand, the bacterial jelly is the moving medium, which, in contact with the sewage, attracts and absorbs the finely divided and some of the dissolved substances, and within its confines subjects them to bacterial decomposition and oxidation.

Character of Resulting Effluent.—The well settled effluent from the aerating tanks as observed by the writer at Milwaukee is clear, sparkling and colorless. It contains ordinarily less than 10 per cent as many bacteria as were present in the original sewage; it is relatively stable, keeping under exacting laboratory conditions for from three to five days, even in the winter when there is practically no nitrification, due apparently to low temperature of the sewage. In warmer weather there should be no difficulty in producing a stable effluent and even a highly nitrified effluent.

Application to Trade Wastes.—This method appears to be adapted to the treatment of certain trade wastes. Experiments being made by the writer upon tannery wastes, give promising results, while those upon paper mill wastes are not encouraging, probably because these wastes are not as susceptible to vigorous bacterial action.

Cost.—It is too early to base estimate of cost of this process upon actual operating data. The expense will apparently be divided into two parts, that of the purification process and that of sludge disposal. Air alone, at the rate of 1¾ cu. ft. of free air per gallon of sewage treated, will cost about $14 per million gallons of sewage, if power costs 2c per k. w. h. Few small cities can hope to purchase power at a much lower cost, and other methods of treatment are likely to prove more economical unless a profit can be realized from the sludge.

Analyses of activated sludge from different experimental plants vary widely. Some indicate the possibility of a return from sale of commercially dry sludge, sufficient to warrant the payment of a substantial sum for dewatering and drying, but what these processes will cost is now problematical.

Comparison of Results of Methods of Sewage Treatment.—Sedimentation with or without screening, is capable of removing much of the suspended matter capable of settling in a short time. Referring again to the hypothetical sewage, by way of illustration, it may be assumed that this process will effect a removal of about 130 parts per million of suspended solids. This leaves 170 parts of suspended solids and 500 parts of dissolved solids—an highly putrescible effluent which is decidedly dirty in appearance. Such an effluent, however, may be turned into some streams and bodies of water without fear of causing serious deposits, and the quantities of diluting water may be such as to fully warrant such a course.

If, however, a better effluent be required, resort may be had to chemical precipitation, by which it is possible to remove colloidal and suspended matters more completely than by sedimentation, and to the extent of perhaps 290 parts per million, leaving 510 parts of suspended colloidal and crystalloidal matter in the effluent of the hypothetical sewage. A large part of this consists of soluble matter. Even this reduction is not sufficient to render the effluent non-putrescible, and it might be added that in most cases where this method has been employed the operating costs have been so curtailed that the results obtained have hardly been comparable with those of which the process is capable.

The quantity of suspended and colloidal substances removed by screens, grit chambers, sedimentation and chemical precipitation may be tabulated as follows:

Coarse screens	5 to 10	parts	per	million
Fine screens	20 to 70	"	"	"
Grit chambers	10 to 40	"	"	"
Plain sedimentation	130	"	"	"
Chemical precipitation	290	"	"	"
Activated sludge, more than	290	"	"	"

All of these methods, therefore, leave in the sewage some suspended and colloidal matter and practically all of the crystalloidal substances. Where further purification is required, methods of oxidation are employed.

The results obtained by bacterial oxidation in sand or stone beds, have varied greatly. The best results can be obtained undoubtedly by the use of sand filters, with which a clear, sparkling non-putrescible effluent can be produced without difficulty. Such an effluent is as good as can be obtained by any of the available processes and may contain no more bacteria than a well disinfected settled sewage.

The activated sludge method produces a clear, sparkling, well-oxidized effluent. Its bacterial efficiency apparently approaches that of the sand filter, as does its power of oxidation and removal of organic matter.

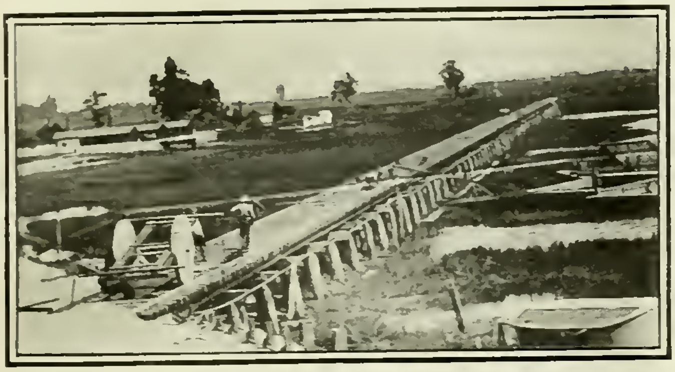
Current Engineering Practice Briefly Recorded

CARTS FOR DISTRIBUTING TIES ON A LONG TRESTLE.

Contributed by W. D. Jones, Assistant Engineer, Harbor Department, Los Angeles, Cal.

In constructing a trestle across a salt marsh at Los Angeles Inner Harbor delivery of material was taken at two points along the trestle, near one end, to which a barge or raft could be floated on high tide and left standing on the mud as the tide went out during the process of unloading.

A small derrick was arranged to lift material off this barge or raft and the stringers were lifted by this means and dollied to their position in the structure. Ties were started either way from the two receiving points but due to the expense in handling by hand a better method was sought to handle them to the more remote portions of the work. A cart was finally tried out, having two wheels of large diameter, and worked very successfully in handling not only ties but various materials used on the work. The wheels were made of two thicknesses of 3-in. planks nailed at right angles to each other and sawed out on a 7-ft. diameter. The axle was made of a $2\frac{1}{2}$-in. pipe on top of which the frame was constructed of 2x6-in. and 2x4-in. pieces. The ties were piled for loading with the length in the direction of travel and supported on two pieces of 4x4-in. with ends extending beyond the edge of the pile. Over these ends a rope was looped which supported the load while in transit. Loading was accomplished by running the cart over a pile of ties made as described and making one supporting rope fast to an end of the cart, the end being lowered to the proper distance from the load, the other end was then raised by a lever and made fast. By this means a pile of 16 to 24 ties could be carried at a trip. The large diameter wheels permitted the load to be underslung and also permitted the load to be carted over the cross ties, already laid, without the use of planks or any other runway which for such a long distance would have been expensive. The cart and trestle are shown in the illustration.



ALLOWANCE FOR EXTRA WORK.*

Some engineers think extra work is a clear "bonanza" for the contractor, but let me give you a few inside facts and figures. A very careful cost account on a reservoir job in New England showed a general expense item of 12.9 per cent of the whole contract. This general expense included superintendence and miscellaneous general labor, insurance, including bond, freight and teaming plant, general office expense (field work), timekeepers, storekeepers, blacksmiths and watchmen.

On five jobs done by us, amounting to $3,000,000 worth of work, the general force was 10.1 per cent of the pay roll.

So we start with the direct cost of work, including labor and material, add to that 10 per cent of the pay roll for general expense, 5 per cent of the pay roll for the use of small tools; also a proper charge for wear and tear of heavy plant; and then in the sum of all these you get the actual gross cost to the contractor of extra work.

Now you generous engineers allow us 15 per cent of the actual cost of work, which includes insurance, a proper allowance for superintendent, watchman and timekeeper, and a reasonable rental for large plant. If there is a lot of material used and plant required, extra work may pay the contractor, but if only labor is used, with no plant, the less extra work done the better off we contractors will be.

But the above quoted clause is a generous one and consequently is seldom used, most contracts providing for only 10 per cent profit, often not allowing insurance as a cost, and no allowance for tools, superintendence or plant. Under such a clause extra work is done at great loss.

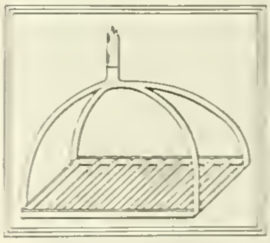
OUTPUT OF TREATED TIMBER IN 1915.

According to statistics compiled jointly by the American Wood-Preservers' Association and the Forest Service at Washington, D. C., there was treated at 102 plants in the year 1915 a total of 141,858,963 cu. ft. of timber. To treat the 141,858,963 cu. ft. of timber shown for 1915 required 80,859,442 gal. of creosote, 33,269,604 lb. of zinc chloride and 4,899,107 gal. of all other preservatives, which included crude oil, coke-oven tar, refined coal-tar, carbolineum oils, etc. Of the creosote used in 1915, 54 per cent or 43,358,435 gal. (41,333,890 gal. coal-tar creosote and 2,024,545 gal. water-gas-tar) was domestic, and 46 per cent or 37,501,007 gal., German and English oil. In 1914 the larger consumption of creosote was met by imports, the falling off in 1915 being explained by the scarcity of foreign supplies due to the European war. The imports of creosote into the United States in 1915 (37,501,007 gal.) were 13,806,729 gal., or nearly 27 per cent less than the previous year.

AN IMPROVED TAMPER FOR CONCRETE.

Contributed by E. J. Borhek, Contracting Engineer, Tacoma, Wash.

Now that the advantages of a drier mix is recognized, the writer has devised a tool for tamping and agitating wet concrete to effect more perfect hydration, re-mix and eliminate the coarser particles of aggregate from the wearing surface. The tamper or agitator is primarily a hand-power tool having two to three times the surface area of the customary flat iron type, and as a consequence a much larger area can be finished in a given time than with the usual type. The tamper can be operated mechanically in batteries and a large amount of surface be covered in a short time. A minimum amount of water can be used in the mix, effecting more perfect hydration with little if any loss of cement due to separation, the elimination of surface water after tamping and the proper placement of the coarse and fine aggregates as regards wearing surface is effected. The re-mixing produced is in itself a great advantage, producing a dense homogeneous mass practically free from air and water voids, destroying any tendency to bridge or pocket and breaking up any lumpy masses of concrete that have a tendency to ball and prevent the admission of water to the lumpy mass. The use of a small aggregate combined with the coarse particles is made possible a small aggregate highly resistant to abrasion can be brought to the wearing surface and an even wear be obtained.



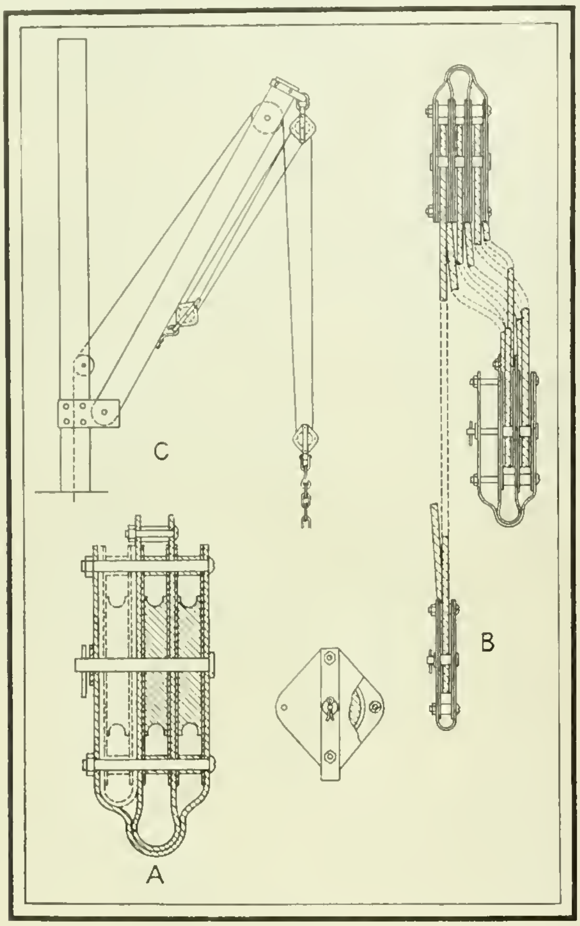
The tool can be made in several shapes and sizes to meet conditions. A flat ribbed surface, square openings, diagonal openings, circular openings, parallel openings or a type acting as a cutter of knife-like blades can be had. Patents have been applied for covering the different types, and it is hoped that the tool will soon be placed upon the market.

---

*J. W. Rollins, of Holbrook, Cabot & Rollins, Engineers and Contractors, Boston, Mass.

ARRANGEMENT FOR CONVERTING A SEVERAL PART FALL TO A TWO PART FALL WITHOUT UNREAVING LINE.

Frequently a single derrick is required to hoist both heavy and light loads. In steel construction for example it is required to hoist say 10-ton loads of steel from the street and then with the same derrick to handle this steel by single light members into place for erection. A five or six-part fall block is required for the heavy load but such a block is too slow and cumbersome for economical handling of the single pieces. To unreave the line and replace the several part fall with a monkey purchase or two-part fall is a tedious task. The device illustrated is designed to permit this transformation without unreaving the line and by a change taking only a few minutes. Referring to the drawing: At A is shown a triple block in which one pulley shown by dotted line is removable and when removed forms a complete single pulley block. To make the transformation this single block is removed as shown at B and the remainder of the original fall block is carried back and hooked to the boom as shown at C. This device is the invention of Charles M. Seacombe, 259 W. 34th St., New York City.



NEW PENETRATION NEEDLE FOR TESTING BITUMINOUS MATERIAL.

A new penetration needle for use in testing bituminous materials has been designed by Charles S. Reeve, Chemist, and Fred P. Pritchard, Assistant Chemist, U. S. Office of Public Roads. The following description is given in the Journal of Agricultural Research: The needle is made by placing a 2-in. length of 0.041 in annealed-steel drill rod in the chuck of a high-speed lathe, and by means of a fine sharp file turning the end to a sharp point having a $^1/_4$-in. taper. When it has been made as smooth and sharp as possible by this means, the needle is tempered, then ground to a sharp point with a good stone, after which it is smoothed and polished with emery dust, crocus cloth and rouge, and finally held carefully on a buffing wheel. The finished needle should be sufficiently smooth and sharp to enter and pass through a piece of ordinary writing paper without sticking or friction. The important thing is to have the taper straight, beginning $^1/_4$ in. from the end and the needle above the taper exactly 0.04 in. in diameter.

COSTS OF INSTALLING CORRUGATED IRON CULVERTS.

Contributed by B. G. Marshall, Armco Iron Culvert & Flume Manufacturers' Association, Middletown, Ohio.

This is a very practical subject to all those who have to do with road work. One of the great advantages of corrugated pipe over other forms of road drainage is the ease with which it is handled and installed. Thus the cost of the completed improvement is often less than that of a construction for which the materials may be more cheaply purchased.

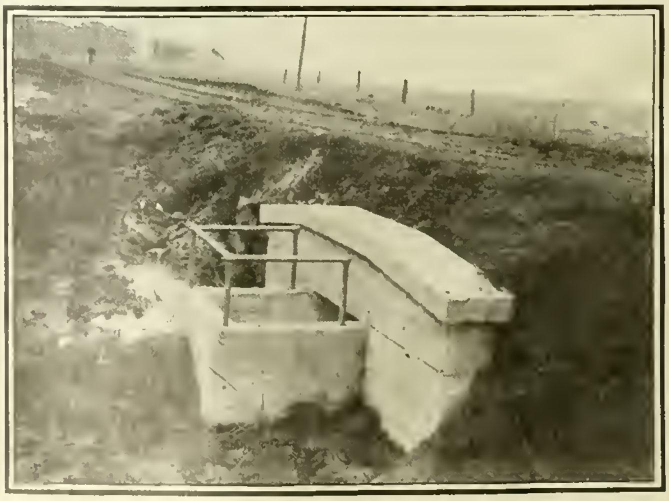
Table I gives the installing costs of a portion of the Armco iron pipes employed by the California Highway Commission during the year 1914, and is based on the engineer's estimate and the lowest contractor's bid. It includes figures from the work of 77 contractors. The figures cover the hauling of pipe from the railroad station to point of installation, the excavation, the placing of the pipe in position and tamping it in place, and the refilling of earth over it.

TABLE I.

Diameter pipe.	Total No. feet on various contracts figured.	Total cost according to engineer's estimate.	Total bid placed by lowest contractor bidding.	Av. cost per ft., engineer.	Av. low bid per ft., contractor.
12-in.	48,516	$26,232.20	$26,088.64	$0.5407	$0.5377
15-in.	1,845	1,132.75	951.55	.6139	.5157
18-in.	35,625	22,441.80	21,542.77	.6299	.6047
21-in.	162	129.60	105.10	.80	.6487
24-in.	16,552	13,247.69	11,930.76	.8003	.7208
30-in.	3,144	3,544.70	2,641.52	1.1274	.8401
36-in.	1,728	1,541.05	2,080.90	.8918	1.2042

A ROAD CULVERT DESIGNED TO PREVENT SOIL EROSION.

A road culvert designed to pond the flow on its upstream side and thus retain the sediment while allowing the water to pass freely is illustrated. This particular culvert is located in Cedar County, Iowa, and was built in 1914, but is only typical of a great many culverts constructed at the instance of the Iowa Highway Commission. The structural features of this culvert require no explanation. By means of the weir entrance the water approaching the culvert is ponded and deposits its sediment thus gradually reclaiming the gully.



DEVELOPMENT OF THE ART OF DRAUGHTING INTO THE BUSINESS OF DRAFTING.*

Orthographic projection was discovered by Gaspard Monge, a noted French mathematician and physicist, and was published by him in 1795. This discovery marks the actual beginning of the method of graphic representation as now practiced by all draftsmen on constructive drawings; for while the ability to represent objects by their projections seems to have been possessed by the ancients Monge was first to perceive and set down the principles by which such projections are made.

During the first half of the century which followed "draughtsmanship" became an art. Fine lines, shading both by lines and India ink wash, ornate borders, and fancy lettering were the style, and the draughtsmen of that period seem to have devoted themselves to the task of making fine drawings for the sake of the drawing itself. And yet while their work was extremely ornate, judged by modern standards and therefore extremely bad, judged by the same standards, it was executed with great accuracy and the utmost consideration for faithful representation. It is to be regretted that so few drawings remain to record the draughtsmanship of that period, but owing to the character of the drawing and the lack of a method of reproduction most of these early drawings were spoiled by the use they got.

During the last half of the nineteenth century came that wonderful industrial development which brought with it great changes in the character of drawings. Military and civil engineering ceased to be designations sufficient to indicate the character of constructive undertakings, and engineering became divided into its present-day branches. With each of these branches of engineering arose a demand for a certain kind and style of drawing, and thus came the day of specialization. Along with these changes came great improvements in drawing materials and the discovery about 1840 and perfection of the blue print process about 1880 for the reproduction of drawings. With this epoch-making event modern drafting came into being; the demands of the high-speed industrial organizations, of which the drafting room found itself a part, became so great that shading, fancy borders, and ornamental lettering could no longer be permitted; drawings became plainer and even severely plain until now only that drawing which tells a complete story in the fewest lines is considered acceptable. Even the name which describes the making of a drawing has suffered from this process of pruning; the art of draughting has been completely lost. but the business of drafting has been discovered!

INCLINATION OF CONVEYING CHUTES FOR CONCRETE.

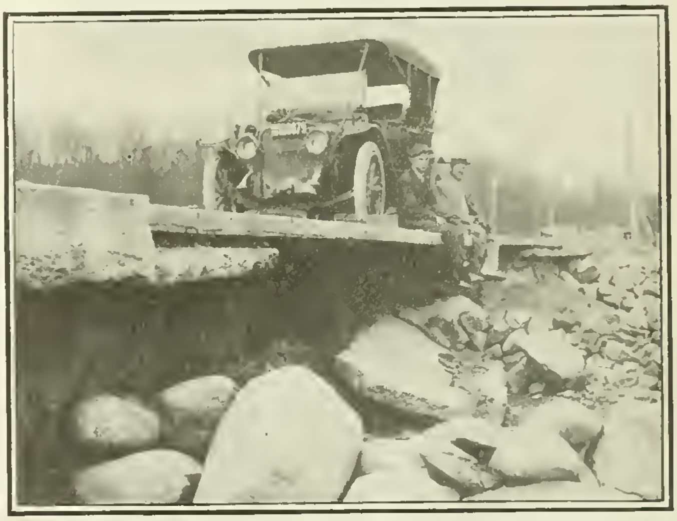
If the concrete reaches the chutes as a homogenous mass the slope of the chutes is not of vital importance. That slope is generally the best which will allow the concrete to flow with the least velocity which will insure its passage, although a vertical drop in a closed pipe is a feature of many installations on important work. Such vertical lines, however, should have baffles every few feet to arrest the drop and the concrete should be distributed at the bottom by means of a horizontal chute whenever possible and not directly from the vertical line into the forms. The required minimum slope to carry the concrete properly will vary with the character of the agregates, the average slope for small, round gravel being 1 of rise to 3 of run, or an angle of about 18 degrees with the horizontal; the slope for 1-in. stone, about 1 to 2¾, or 20 degrees; for 1½-in. stone, 1 to 2½, or 22 degrees; and for 2-in. stone, 1 to 2¼, or 24 degrees with the horizontal. It is better practice on a long line to hang the chutes with a gradually and very slightly increasing grade as they travel toward the lower end, such a grading being less likely to cause an overflow in the chutes than the reverse. The final distributing section which places the concrete in the form should retard the concrete to as slow a movement as will carry it at all.

"CONDENSED INK" FOR CAMP USE.

Although large quantities of writing ink are not ordinarily used in any surveying or construction camp, it may often be wise to reduce both the burden of transporting ink and more especially the danger of losing it by the breaking of bottles in transit. Ink tablets can be secured at 10 ct. per dozen, packed in a small vial. About 13 ct. worth makes a quart of ink. A few tablets are put into an inkwell full of water and stirred.

STRENGTH OF AN UNDERMINED BRICK PAVEMENT.

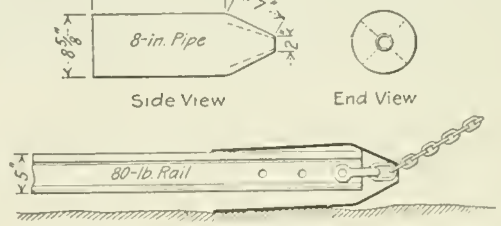
An interesting demonstration of the solidity of a grouted brick pavement was afforded by an accident this spring to one of newer highways of Wayne County, Ohio. A road near Wooster skirting a small stream known as Killbush Creek was overflowed for many hours. The embankment supporting the road was gouged away by the swift current for several hundred feet. For a length of 60 ft., and a maximum width of 6 ft., the concrete base was undermined and fell away, leaving nothing but the brick surface. This shelf, however, as is shown in the illustration, was sufficiently strong to support a good sized automobile and two men.



A further and perhaps more severe test of the rigidity of the brick shell occurred when the reconstruction was started. In preparing to refill the wrecked embankment large boulders were hauled, dumped upon the pavement and then rolled over the protuding edge to the cut underneath. This was accomplished without disturbing a brick. The road will be constructed up to the pavement thus reversing the customary order of things.

A SHOE FOR SNAKING RAILWAY RAILS.

For short hauls it is often cheaper to snake railway rails by team than it is to load and tram them. With any ordinary snaking hitch, however, the rail is promptly converted into a plow and proceeds to uproot everything between start and destination. To avoid this trouble at the Oliver iron mines at Hibbing, Minn., Mr. L. D. Davenport has used the snaking shoe illustrated by the accompanying sketch reproduced from the Engineering and Mining Journal. This device is simple and easily made and should be useful to contractors.



Side View

End View

Section of Shoe in Use

---

*F. H. Higbee, Professor of Mechanical Drawing, University of Iowa, in the "Transit."

PREVENTION OF WATER WASTE IN RAILROADS.

American railroads consume daily approximately 1,950,000,000 gal. of water at a daily expense of over $100,000. These figures should be enough to convince almost anyone that water is not free, and that a saving in water is quite as important as a saving in coal, oil or other supplies. It is safe to say that 15 per cent of all the water used by railroads is waste. By waste is meant that quantity of water drawn in excess of the amount actually required.

An example of what may be accomplished by a campaign against water waste, says C. R. Knowles in the Journal of the American Water Works Association, the Illinois Central has reduced the expense for city water alone from $225,112.94 during the fiscal year 1913-14 to $190,438.50 during the fiscal year 1914-15, a reduction in the cost of city water of $34,673.79. This is a net saving accomplished by the elimination of water waste. The expense for city water represents only about 40 per cent of the total cost for water, 60 per cent being for water pumped by company forces, consequently there has been a great reduction in the waste of water pumped by railroad water stations, and a resultant saving that cannot be shown by figures.

TREE PLANTING BY MACHINE.

A machine which plants from 10 to 15 thousand forest tree seedlings a day is now being used at the Letchworth Park Forest and Arboretum, in Wyoming County, N. Y., according to officials of the Forest Service who are acting as advisers in the work. Previously the planting has been done by hand at the rate of 1,200 to 1,500 trees each day per man. The machine was designed to set out cabbage and tomato plants, but works equally well with trees. It is about the size of an ordinary mowing machine and is operated by three men and two horses. One man drives the team while the other two handle the seedlings. The machine makes a furrow in which the trees are set at any desired distance, and an automatic device indicates where they should be dropped. Two metal-tired wheels push and roll the dirt firmly down around the roots. This is a very desirable feature, it is said, because the trees are apt to die if this is not well done. Two attachments make it possible to place water and fertilizer at the roots of each seeding. Another attachment marks the line on which the next row of trees is to be planted. No cost figures are available yet, but officials say that the cost will be much less than when the planting is done by hand. It is stated that the machine can be used on any land which has been cleared and is not too rough to plow and harrow.

OBJECTIONABLE CLAUSES IN CONTRACTS.*

(1) Disclaiming responsibility for soundings and other information as to the character of the work.

(2) The insertion of the clause which may make any contractor's estimate and bid worthless—"Or as otherwise directed."

(3) Making contractors responsible for work for which the engineers make the plans, or require the approval of the engineer to any made by the contractor for temporary work, and where the engineers reserve the right to entirely control the manner and means of construction.

(4) Holding the contractors responsible for work which has been built under the direction of the engineer, and passed inspection, unless fraud and gross negligence is proved.

(5) Making the engineer the sole referee in settling all claims.

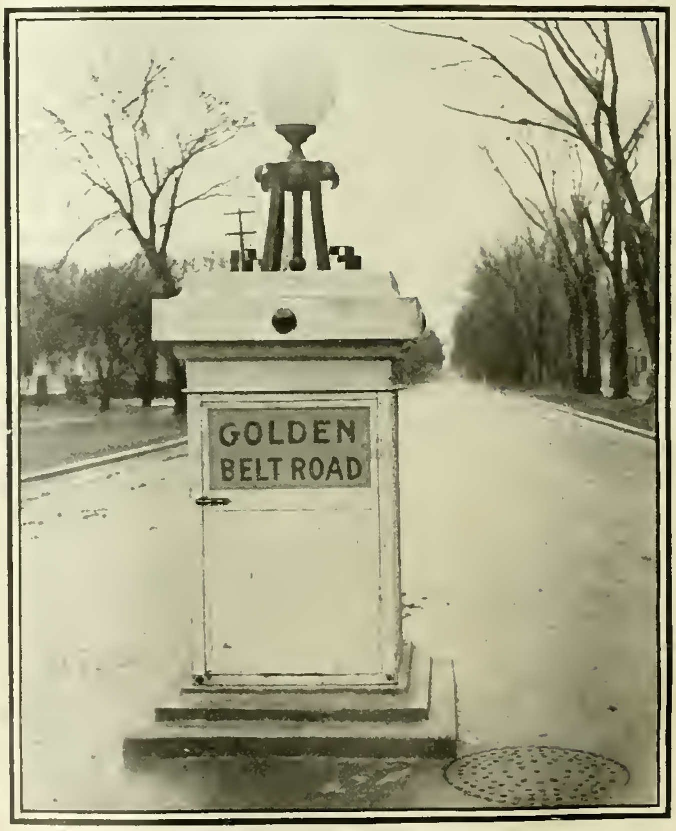
(6) The right to stop work or any part of it, if for the interest of the engineer so to do, without allowing the contractor any compensation for such action.

In the opinion of the writer, none of the above objectionable clauses afford any protection to the engineer against a bad contractor, but do hold out a threat and often work a great injustice to a fair contractor.

A COMBINED ELECTRICALLY OPERATED TRAFFIC SIGNAL AND AUTOMATIC SEWAGE PUMPING STATION.

Contributed by Frank C. Perkins, Buffalo, N. Y.

The illustration shows a combined electrically operated traffic signal and automatic sewage pumping station, developed at Abilene, Kansas, by Engineers Karl Riddle and Kenyon Riddle. Originally there was located here a receiving well, with an automatic air-lift pump at one side of the street. This device was never satisfactory and later on the pump was abandoned and an electrical motor and centrifugal pump were installed. On account of the moisture within the cistern the motor gave considerable trouble. Also, occasionally, the creek would rise high enough to flood the cistern and at such times, if the motor were not out, it would be seriously damaged and the pump would be out of commission for a time. As the principal objection to the second plan was found in the placement of the motor, the first thought was to invent a scheme for placing the motor in a dry place. This lead to an attempt to put the motor over the manhole or receiving well already placed in the intersection of the streets. It was learned that a suitable motor could be had, which with the housing would not occupy too much space for the street intersection, and that it could also serve as a traffic signal, thus concealing the fact that it served for any other purpose. The intersection was located in the best residence district of the town.



The housing is 30 in. wide at the base and the entire height of the housing and lamp standard is 8 ft. It is built of sheet metal and rests on a concrete base. The motor sets on a concrete foundation 8 in. above the pavement grade. It is a 5-HP., 3-phase, 220-volt motor with vertical driving shaft, driving a 120-gal. per minute centrifugal pump (2-in. suction) at 800 r. p. m. It starts automatically, by means of a float, when the sewage is 8 ft. above the bottom of the cistern and stops automatically before the suction pipe is uncovered. It runs about four hours per day. The cost of electricity is 7 ct. K.W., and so far this has been the only cost of operation. The motor and pump cost $260 and the housing and pump $75.

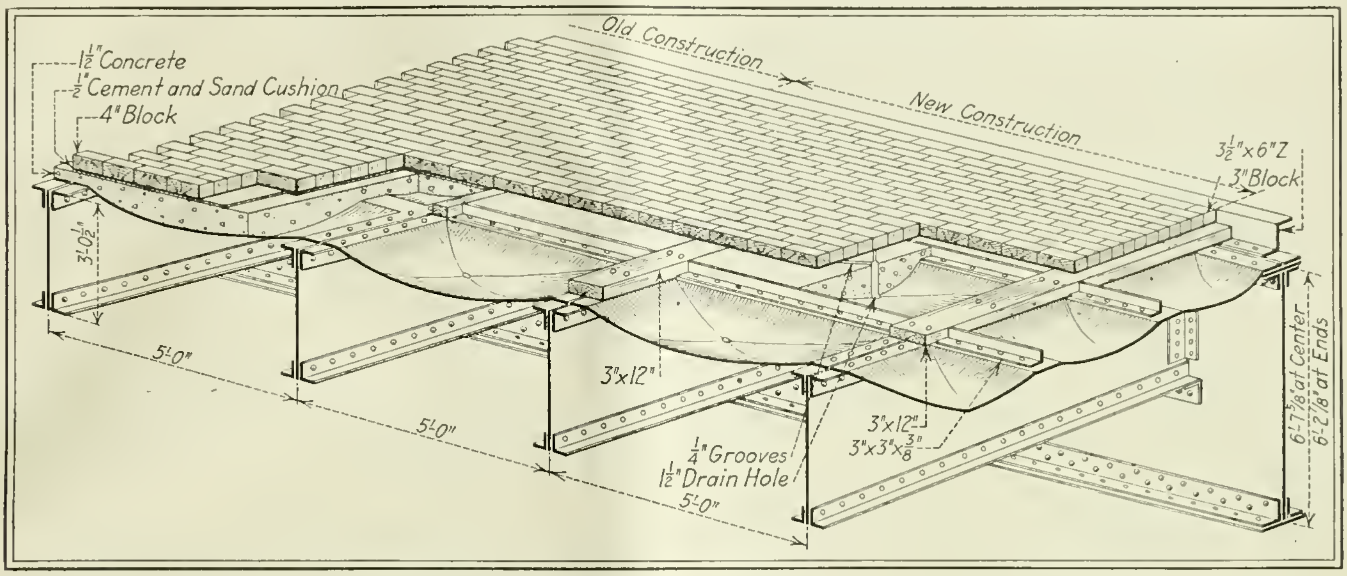
---

*J. W. Rollins, of Holbrook, Cabot & Rollins, Engineers and Contractors, Boston, Mass.

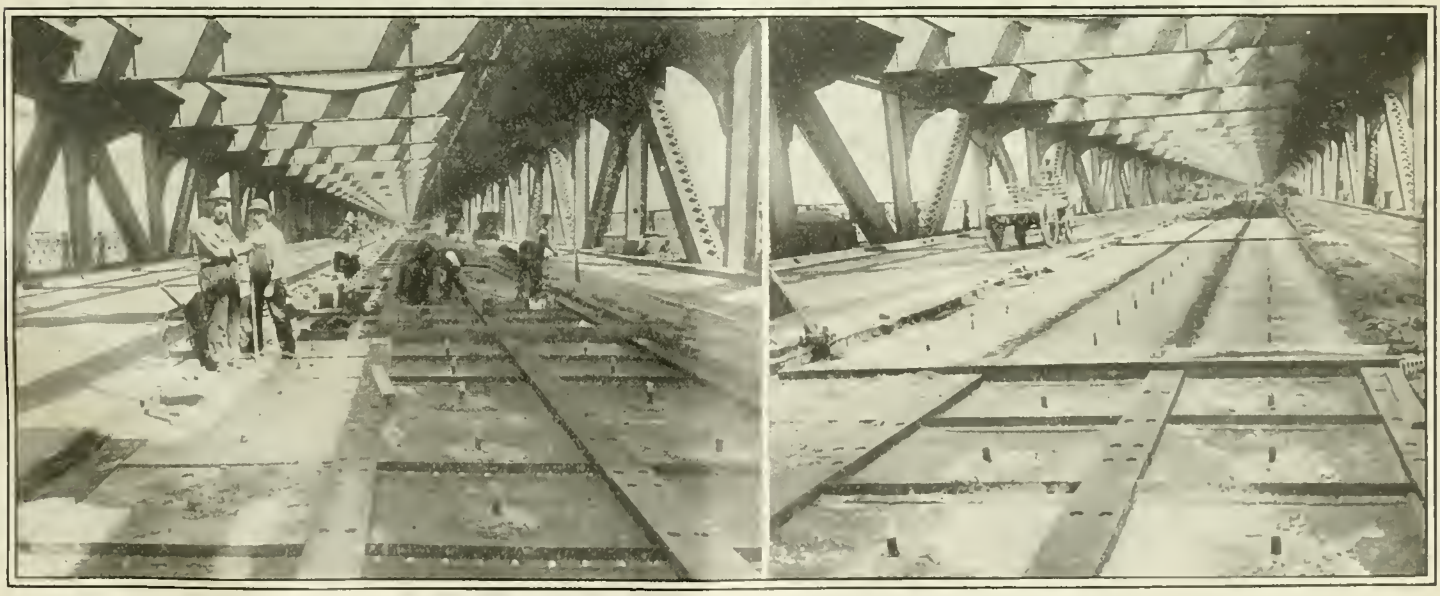
NEW PAVEMENT CONSTRUCTION ON QUEENSBORO BRIDGE, NEW YORK CITY.

A bridge repaving undertaking of unusual interest is now being carried out by the Department of Plant and Structures of New York City. This one calls for the reconstruction of the pavement in the Queensboro Bridge. This structure spans the East River and has a total length of 7,448 ft. Of this 5,960 ft. are to be repaved. The original pavement consisted generally of treated wood blocks on a concrete foundation. This foundation rested in different bases at various sections of the bridge. On one approach the base is of reinforced concrete, which in turn supported a water proofing protected by common brick in which a 6-in, pavement foundation was laid. On part of the other approach the 6-in. concrete foundation rests on earth fill and part on buckle plate floor. On the main bridge buckle plates supported the concrete foundation. The total area of the wood block pavement is 43,240 sq. yd. of which 8,640 sq. yd. is laid on reinforced concrete and earth fill. This part of the pavement has caused very little trouble since the roadway was opened to traffic in March 30, 1909. The part laid on buckle plates, however, has been a source of much inconvenience to the traveling public and of much anxiety to the city officials.

The design of the roadway floor where buckle plates are used calls for the placing of these plates on stringers having a top flange width of 12 in. spaced 5 ft. on centers. The plates were laid with buckle down. On this floor the 1:3:6 concrete base was laid; the depth of this foundation, for the greater part of the roadway, varying from $1\frac{1}{2}$ in. to $4\frac{1}{2}$ in. On this concrete a cushion of very dry cement and sand mortar, ½ in. in depth, was spread and its surface struck with a straight edge. The wood blocks were laid at right angles to the center line of the bridge with ⅛ in. joints. The blocks were treated by the creoresinate process. They were 4 in. in depth, cut from sound long leaf yellow pine planks 4 in. thick and from 7 in. to 9 in. wide. The joints were filled with bituminous paving cement.



For the first two years of service this pavement required but slight attention, but the constantly increasing traffic commenced to affect the foundations quite seriously. The buckle plates, under the heavy traffic, continually deflecting, caused the concrete to crack at many points. The pavement over the stringers maintained its almost original position. The lean mixture of concrete also was a further cause of the failure of the pavement, and the sand and cement mortar cushion likewise was a source of trouble.



In designing a new foundation the engineer had to take into consideration that no increase in the weight of the floor could be made, nor could the buckle plates be replaced on account of the rigidity they added to the general stability of the bridge. The plan of reconstruction as finally worked out, in general, consists essentially of a parquet foundation, formed by a combination of timber planking and concrete, with the creosoted wood blocks laid directly on this foundation, without a sand cushion. The timber planking of 3 in. by 12 in. long leaf yellow pine is laid flat and bolted to each line of stringers by machine bolts spaced 30 in. apart. The heads of the bolts are finished flush with the top of the plank and the countersunk hole around the head filled with Portland cement mortar. Planks will be similarly bolted to each floor beam with the result that a trough is formed, the buckle plates forming the bottom. This space will be filled with a 1:2:4 concrete, the top of which will be finished smooth with the timber plank. The holes in the invert of the buckle plates will be used for drainage by placing galvanized iron thimbles in them, which will extend to a point just below the finished top of the concrete. The creosoted wood blocks will be laid on this foundation, a sand joint being used. The blocks will be 3 in. in depth and cut from 3 in. by 8 in. long leaf yellow pine timber. Transverse angles will be installed at each floor beam to check longitudinal movement of the pavement. The accompanying sketch shows the new and the old types of construction.

These experimental sections, constructed as noted above, were put down in 1913 and one section in 1915. All of these have given excellent results. The work is being done by departmental labor under the supervision of Edward A. Bryne, acting chief engineer of the Department of Plant and Structures, the designer of the method of reconstruction.

SHAM SHOVEL RECORDS ON A LARGE CUT FOR TRACK DEPRESSION.

A 900,000 cu. yd. cut, which eliminates 39 crossings at grade in Minneapolis, Minn., is shown by the accompanying view loaned us by The Excavating Engineer. In this work the tracks were lowered to give a clearance under bridges of 18½ ft.; this necessitated a cut averaging 22 ft. in depth. The work was done by the operating department of the Chicago, Milwaukee & St. Paul R. R. with company forces.

The total depth of the cut was made in from 5 to 7 cuts, depending upon the depth carried. These cuts were generally carried for a stretch of about eight blocks at a time. The usual method of procedure was to use one track as a loading track while the shovel was making as deep a cut as possible to one side. This usually averaged about 8 ft. When this cut was completed to the required distance, a new track was laid here and used as a loading track while the shovel was shifted to the other side.

The shovel used was a 65-ton Bucyrus equipped with a 2½-yd. dipper. This shovel was shipped from the manufacturer's shops in the spring of 1907 and has been in steady service for the past eight years. In connection with this shovel, three dirt trains were used consisting of 25, 12-yd. Western air dump cars. Each train was hauled by a class C-2 (2-8-0) locomotive.

Below is a statement, prepared by J. G. Wetherell, assistant engineer, who was in direct charge of the work, for the operating department, for shovel operation from April 19 to July 23.

Total amount of excavation for season, cu. yd.	195,908
Total number of dadys shovel worked	82
Number of cuts shovel made	8
Total distance shovel excavated (total length of [illegible]	16,076
Average distance excavated per day shovel w[illegible]t	196
Average number of hours shovel worked per day	8.80
Total number of cars loaded	17,107
Average number of cars loaded per day	208.6
Average number of cu. yd. per car, cu. yd.	11.46
Average number of cu. yd. excavated per day	2,389.1
Average distance excavated material hauled, miles	5.28
Greatest excavation for 1 month (June), cu. yd.	72,934
Average daily excavation for June, cu. yd.	2,805

Delays amounted to 12 per cent of the total time, distributed as follows: 3.4 per cent, moving shovel from one cut to next; 5.3 per cent, no cars, due to trouble at the dump or to main line being used for other purposes; 1.3 per cent, rain; 0.2 per cent, shovel breakdowns; 0.8 per cent, derailments in cut; 1.0 per cent, miscellaneous.

METHODS FOR STATE ROAD MAINTENANCE IN STEELE COUNTY, MINNESOTA.

Steele County, Minnesota, has 58 miles of improved state roads with gravel surface and 55 miles of unimproved state roads with some stretches having a light gravel surface and the rest with earth surface. The following description of the method of maintaining these roads is taken from the Minnesota Highway Journal.

The 58 miles of gravel surfaced roads are maintained by eight sections working under the supervision and direct control of the District Engineer. The sections are from 5 to 8 miles in length, depending on the amount of traffic. Under the system the cost of keeping the roads in good condition has been from $110 to $125 per mile per year. The gravel also is being renewed under this system at the rate of 100 cu. yd. per mile a year, and it is estimated that this will take care of the wear on the surface up to 300 cars a day for 5 or 6 months of the year.

Section men are hired by the month and devote their entire time to the road work. At the present time they are being paid $95 per month (in the county the going wages are $4.50 per man and team and $2.25 for laborers per day). It has been found that under the monthly system better results are obtained than by day work, as each section man alone is responsible for the upkeep of his section, which creates a certain amount of rivalry between them to have the best stretch of road.

The unimproved and earth surfaced roads are taken care of by drag foremen, most of whom are farmers. They have stretches of road from 3 to 5 miles in length. Roads are dragged whenever necessary, this being left to the discretion of the drag foremen. Dragging is paid for at the rate of 75 cts. per mile for one round trip. The dragmen also fill all washouts and sink holes by day work. The maintenance of the unimproved and earth surfaced roads averages about $30 per mile per year. These roads are not in very good condition during wet weather. The soil is a black loam and very little travel carves it up badly in wet weather.

The instructions to the road section foremen include the following:

Dragging to be done after each rain and to be continued until all ruts are filled, and the road hard and smooth.

Section men are to patrol their entire section at least once a week. Ditches are to be kept clean and free from obstructions at all times.

Reshaping to be done in the spring and after rains.

Washout and sink holes to be repaired with stone, cinders or coarse gravel.

The general classification of the work of the section men is as follows:

Patrolling: Go over section on foot with hand tools, right after rain, letting off all standing water and marking all such holes so that they can be easily found when road is dry and filled with gravel. Picking loose stones off of the road and piling them in neat piles outside of ditch line. Inspection of ditches and culverts.

Ditches: Cleaning side ditches with grader or by hand. Making or cleaning runoff ditches from culverts.

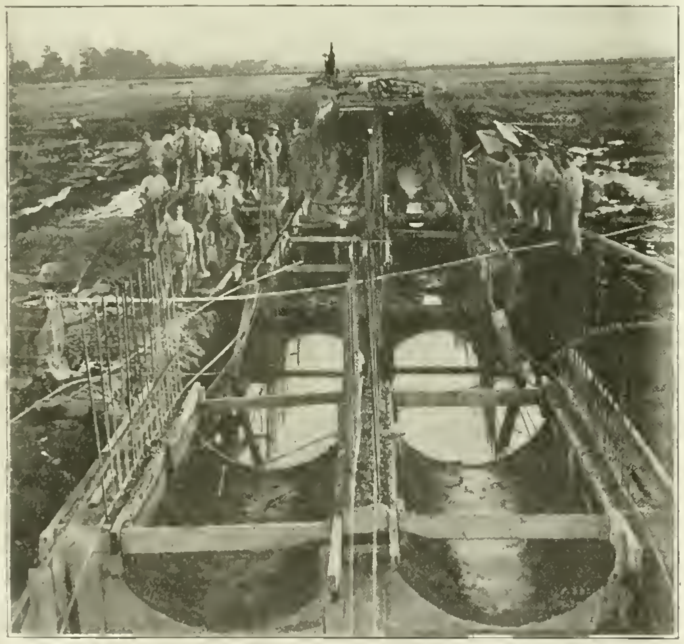
Reshaping: Leveling and reshaping road with grader. Cutting off sod shoulders with grades. Cutting grass inside right of way.

Weeds: Cutting and burning brush or willows inside right of way. Cutting and burning all weeds inside right of way.

Washouts: Repairing holes caused by rain or upheaval of frost. Repairing culverts, hauling and spreading gravel.

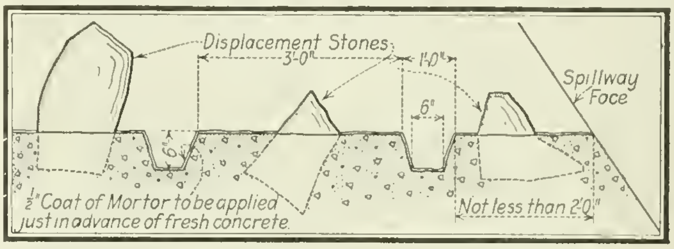
DOUBLE SEWER CONSTRUCTION, USING PORTABLE CULVERT FORMS.

The illustration shows a sewer being constructed in the Bronx district in New York City. Each sewer has curved invert, vertical sides and a flat top, and the two sewers are built side by side with a common dividing wall. As constructed the invert portion was built first as illustrated, using invert templets and timber forms. Alternate sections of invert were concreted and then the gaps between were filled in. After completion of the invert section, side walls, center wall and roof were concreted in one operation, using two traveling steel forms set side by side. These forms were regular box culvert forms, with carrier, adjustable to three sizes, 7½x5 ft., 5x5½ ft., and 5x5 ft. A total of 80 ft. of forms for each sewer was used. The carrier was 20 ft. long, so that the forms were collapsed, moved ahead through the standing sections and re-erected ahead in 20-ft. sections. The sewer was built by Joseph Rotti, sub-contractor under Joseph Sigretto, general contractor. The forms were furnished by the Blaw Steel Construction Co., Pittsburgh, Pa.



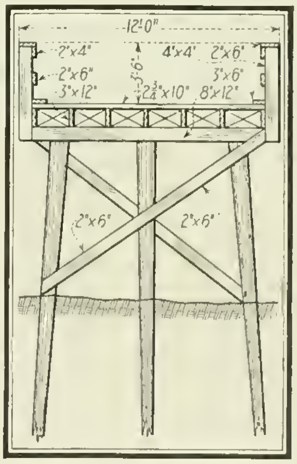
HORIZONTAL JOINT CONSTRUCTION FOR RUBBLE CONCRETE DAM.

The rubble concrete dam designed for the Fort Dodge, Iowa, hydro-electric power development is of ogee section and is faced with 6 to 12 in. of 1:6 gravel or broken stone concrete. Concreting is required to be carried up horizontally and, at the level where work is discontinued to be resumed after the concrete has set, the top surface is required to be constructed to bond into the new concrete subsequently placed. The illustration shows a typical construction joint plan. Besides the formed grooves in the concrete surface, special rubble stones are partly embedded and left projecting like teeth to bond into the fresh material. Also just before the new concrete is placed the old concrete surface is required to be scrubbed and flushed and left well wetted and then a ½-in. coat of mortar placed just in advance of depositing the new concrete. The engineers of this work are Burns & McDonnell, Kansas City, Mo.


Displacement Stones
3'-0"
1'-0"
6"
Spillway Face
½" Coat of Mortar to be applied just in advance of fresh concrete
Not less than 2'0"

A LONG PILE TRESTLE CAUSEWAY.

From Rockport in Aransas County, Texas, to Bayside in Refugio County, is 50 miles by road owing to the necessary detour around Puerta Bay. To bring the two towns within an hour's easy ride a trestle causeway is being constructed and the first link of 2,940 ft. has been completed at a contract price of $25,000. Nominally, the section is that illustrated, but at turnouts which are located some 700 ft. apart a four-pile bent construction giving a roadway width of 18 ft. is employed. All dimensions are shown by the drawings. Pine lumber was used with all joints and laps treated with Reeves' wood preserver. Galvanized nails and boat spikes were used to resist rust. At the contract price named the trestle cost about 70 ct. per square foot of roadway area. The next longest trestle will be 2,100 ft. The contractors for this causeway system are Austin Brothers of Dallas, Texas.



Elephant Butte Dam.—In the category of world-famous dams Elephant Butte dam stands pre-eminent as a flood conserver. Its height, 318 ft., is topped by Arrowrock dam, 350 ft., and Shoshone dam, 328 ft., are Service achievements. Elephant Butte in the capacity of its reservoir, however, ranks every other storage dam in the world completely controlled by man. Its reservoir when full will contain 856,000,000,000 gal., or enough to cover Delaware 2 ft. deep. This is a third more than is stored by the $17,000,000 Assuan dam in Egypt and two-thirds more than the combined capacity of all the reservoirs built or projected for Greater New York City. On top Elephant Butte is 1,674 ft. long; it contains 610,000 cu. yd. of rubble concrete and weighs a million tons. Placed on a city lot 25 by 125 ft. it would make a block of concrete lacking only 50 ft. of being a mile high. It cost approximately $5,000,000.

A $5,000,000 HYDRO-ELECTRIC DEVELOPMENT IN ARKANSAS.

Preliminary engineering work has been completed for a $5,000,000 hydro-electric development on the Little Red River in Arkansas. The project involves the construction of a dam near Heber Springs. According to this report of the engineers a dam at this point with a 150-ft. head will give a basin of 23,000 acres. This reservoir will store in a 20-ft. available drawdown 17,424,000,000 cu. ft., capable of developing 22,670 continuous horsepower across a drouth period of 104 days, and can be refilled three times a year from the runoff of the average annual rainfall as recorded for the last 3 years. After deducting transmission losses this would place on the switchboards at Little Rock and Memphis, and at intermediate points in the territory, 126,582,000 kilowatt hours per annum. By utilizing the regulated stream below with its additional watershed, and where another 76-ft. head is available, making a total of 226 feet, the output may be increased to 197,840,000 kilowatt hours.

The site of the principal dam is about 3 miles northeast of Heber Springs, at a point where the stream flows between two mountains of sandstone, solid ledges 20 ft. thick cropping out of the bluffs. This sandstone is hard and quite suitable for concrete, while the sand can be readily and cheaply formed by crushing it. The Missouri & North Arkansas R. R. passes within 2 miles of the site, from which a spur can be built without difficult construction, to bring in materials and machinery. An alternate plan contemplates a storage dam at Higden. A 65-ft. dam here will store 10,000,000,000 cu. ft. of water available for use at a power dam of 80-ft. near Heber Springs. With installations at both Higden and Heber Springs the plant would develop 19,000 hp. The complete development, with dams at Pangburn and Hall's Shoals also, contemplates an installation of 39,000 kilowatts, with transmission lines to both Little Rock and Memphis, and would give a net output of 180,945,000 kilowatt hours per annum. The Arkansas Hydro-Electric Development Co. has been organized recently to carry out the development. Dickinson & Watkins, Little Rock, Ark., are the engineers.

PERSONALS.

Harold A. Rands has been re-elected water commissioner of Oregon City, Ore.

Hal Brown has been promoted to the position of field engineer for the Department of Public Works at Duluth, Minn.

T. C. Edminster, formerly assistant county engineer of Harris County, Texas, has been appointed engineer of Precinct No. 3 of that county.

W. L. Hastie, of Lawrence, Kans., has been appointed superintendent of construction for the Masonic office building and library now being erected at Topeka, Kans.

John Thompson, chief engineer of the water works department of Rock Island, Ill., has resigned that position and will be succeeded by N. J. Holtzner, assistant engineer.

Samuel G. Dixon, of Philadelphia, commissioner of health for the State of Pennsylvania, has had the honorary degree of doctor of science conferred upon him by Lafayette College.

Wm. J. Cunningham, a member of the faculty of Harvard University, has been appointed professor of transportation at the university. This department is in memorial of James J. Hill.

The honorary degree of doctor of science has been conferred upon George J. Ray, of East Orange, N. J., chief engineer of the Delaware, Lackawanna & Western Railroad, by Lafayette College.

B. M. Loughead, formerly engineer for the Robert Grace Contracting Co., Pittsburgh, Pa., has been made locating engineer for the Pennsylvania R. R. and will make surveys for a line from Wheeling, W. Va., to Mariana, Pa.

Francis C. Shenetion has resigned his position as dean of the College of Engineering and professor of civil engineering at the University of Minnesota and will devote his entire time to his practice as consulting hydraulic engineer.

Robert E. Frell has been placed in charge of construction work at Government Dam No. 39 in the Ohio River, for the U. S. War Department. He relieves Capt. Harry A. Finch, who has been general superintendent of the work, and who has been ordered to report for duty with the United States Army on the Mexican border.

George T. Snyder, of McKeesport, Pa., chief engineer of the National Tube Co.'s works in that city, has been appointed chief engineer of the company's works in Lorain, O., where he will succeed Charles Waterman, who goes to the new plant of the United States Steel Corporation at Gary, Ind., as general manager. A. L. Hoerr, for a number of years steam and hydraulic engineer, succeeds Mr. Snyder as chief engineer of the McKeesport plant.

M. F. Fasenmyer has been appointed road superintendent of Blair and Cambria Counties for the State Highway Department of Pennsylvania. Mr. Fasenmyer has been with the Department for the past five years, is a graduate of Lehigh University, and prior to coming to the State Department had 5 years' experience in railroad work. He has heretofore been attached to the District Office of the State Department at Franklin as draftsman, and prior to that as chief of party.

Ernest Stenger has been appointed general superintendent of the Union Pacific system with headquarters in Omaha, Nebr. Mr. Stenger is a graduate of the University of Michigan. His first work was in the office of Andrew Rosewater, city engineer of Omaha. Later he became assistant city engineer and about ten years ago left the employ of the municipality and went into railroad work. He had charge of double-tracking in the vicinity of Grand Island for the Union Pacific and continued in the engineering department of that railroad for several years. Later he was assistant superintendent and then superintendent of the St. Joseph & Grand Island R. R. and was then promoted to the position of general manager.

Edgar K. Ruth, of the City Engineering Department of Cincinnati, O., has been appointed assistant professor of civil engineering in the College of Engineering of the University of Cincinnati. Mr. Ruth will resign from the city employment on September 1st to go to the university. He was graduated in 1909 from Rensselaer Polytechnic Institute. From September, 1909, to September, 1911, he was with the New York Central & Hudson River R. R. in New York City as a designer of masonry for Grand Central Terminal improvements; September, 1911, to June, 1912, he was assistant engineer with Kaps-Brehm Co., Cincinnati, on design and construction of National League Baseball Park, also on construction of Gilbert Ave. Viaduct. Since June, 1912, he has been assistant engineer in Division of Structures, Engineering Department of the City of Cincinnati, in charge of office and design of bridges, viaduct and grade crossing elimination projects, bath houses, etc.

OBITUARY.

Charles H. Cartlidge, bridge engineer of the Chicago, Burlington & Quincy R. R., died June 14 at his home in Hinsdale, a suburb of Chicago. He was born in Hannibal, Mo., in 1869. He entered the service of the C., B. & Q. R. R. in 1890 as draftsman in the bridge department and in 1902 was made bridge engineer.

Bartholomew Crowley, a pioneer railroad contractor of northwestern Iowa, died June 16, at his home, 1315 West Fifth St., Sioux City, Ia. Mr. Crowley was a member of the firm of Crowley & Kennedy, which constructed the grades and roadbeds of many railroad lines leading into Sioux City. He was 78 years old and is survived by a wife and seven children.

George Gilmour, for the past 11 years head of the engineering and construction department of the Travelers' Insurance Company, died June 15, at his home in Flatbush, Brooklyn, N. Y. He was formerly mechanical engineer to the New York Telephone Company; he also served as consulting engineer of the New York Commission on Employers' Liability and Causes of Industrial Accidents; he was a member of the American Society of Mechanical Engineers, the American Museum of Safety, the Engineers' Club of New York and many other societies.

Anson D. Houghton, an Eastern mechancal engineer, died at Santa Cruz, Cal., on June 6, aged 51 years. He came to California about 10 years ago. Previous to that he was the architect and builder of the Rockefeller Hall Library. He also designed the heating and electric light plants of the University of Chicago, the power plant and water system of the Bryn Mawr College and the heating plant of Wellesley College. During the Spanish-American war he was assistant engineer at the Boston Navy Yard. Recently he has been superintendent of industrial training in varicus schools of the Southern States under the John Slater fund for the advancement of negro education. He is a graduate of the University of Maine.

NEW CATALOGS.

Steel Tanks.—Paper; 5½x8½; 24 pp. Pittsburgh-Des Moines Steel Co., Pittsburgh, Pa.

This is the newest publication of this company on steel tanks for industrial and fire protection service. It contains several pages of engineering and cost data which should be of interest to the executives of large manufacturing plants; also industrial engineers.

Permanent Concrete Roads.—Paper; 5x8 in.; 128 pp. Trussed Concrete Steel Co., Youngstown, O.

This is the Kahn Road Book. The 128 pages are principally devoted to useful information and illustrations on concrete road construction. The first part of the book contains a general historical review of concrete pavements with detailed information regarding particular sections such as Wayne County, Michigan, and surrounding suburbs. Tables are shown giving cost data as well as summary of yardage and mileage throughout the country. The reinforcing of concrete pavements is freely discussed and information on Kahn road mesh is included. The necessity and advantage of expansion joints with the necessity of protecting the edges occupy another section of the book, including in it practical information in regard to Kahn armor plates and installing device. Complete specifications with interesting illustrations on concrete highways occupy the next section of the book. The one-course concrete highway, the one-course concrete street pavement and the two-course concrete street pavement are covered by these specifications. Diagrams covering templates, bridges, etc., are included. Of interest in connection with pavement construction are concrete curbs with methods of protecting the edges and the installation of these curb bars, also concrete culverts, bridge floors, etc. This information, together with tables giving quantities of materials for concrete and mortar are included in the general Kahn Road Book. The Kahn Road Book is issued primarily for engineers and contractors interested in pavement and road construction, including city engineers, contractors, county engineers, road commissioners, etc. To such persons the Kahn Road Book is sent on request by addressing the Trussed Concrete Steel Co., Youngstown, O.

INDUSTRIAL NOTES.

At a meeting of the Packard board of directors last week Henry B. Joy was elected chairman of the board and Alvan Macauley was formally elected president.

F. A. Peckham & Co., Chicago, Ill., have opened an office in the Leader-News building, Cleveland, O., and in addition to their regular line of locomotive cranes, steam shovels, locomotives, cars, etc., they have added a line of motor trucks, and will make a specialty of a machine which they will announce later which is especially designed and built for the contractors' trade. Fred Peckham will give his personal attention to the management of this office for the next few months.

The U. S. War Department has placed orders with the Russell Grader Mfg. Co., Minneapolis, Minn., for machinery to be used in constructing roads on the Mexican border. An order was placed on May 24 for two carloads of big machines, consisting of the largest size elevating graders, Russell mogul road machines with 12-ft. blades and road plows. The above shipment was ordered to go forward by Wells-Fargo Express and is probably the largest express shipment of its kind that ever moved from the northwest. The total weight was approximately 50,000 lbs., aggregating express charges of $3,100.25. The shipment completely filled two express cars. The entire shipment was put under way within forty-eight hours. On June 19 an additional order was given by the War Department for three more of the large size elevating graders. This last shipment will move from the factory this week. It is understood that the Russell machinery is to be used to rebuild an old railroad right-of-way now used as an automobile road to the American army base at Casas Grandes, over which the military supplies are being hauled by automobile trucks.

Author

Title Engineering-Contracting

Vol. 45, Jan-June/~~17~~16 144616

UNIVERSITY OF TORONTO
LIBRARY

Do not
remove
the card
from this
Pocket.

1 to cy.

Acme Library Card Pocket
Under Pat. "Ref. Index File."
Made by LIBRARY BUREAU